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THE IMPROVEMENT OF EAST RIVER AND HELL GATE.

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THE East River is a most important factor in the commercial prosperity of the cities of New York and Brooklyn. Its shores form a large portion of the water-front of both cities, and afford space for many miles of docks. Its channel is scoured by strong tides, which keep it permanently free from shoals of sand and mud. It connects the waters of New York Bay with those of Long Island Sound, and is the most important avenue of coastwise trade in the United States. Since the partial removal of the obstructions in Hell Gate, a very heavy foreign trade has taken this route, notably the petroleum traffic, and, with the completion of the designed improvements, the East River will afford a convenient access for transatlantic steamers. The value of this entrance to New York Harbor will be still further enhanced by the opening of the Harlem River to the Hudson, the preparations for which are now in progress.

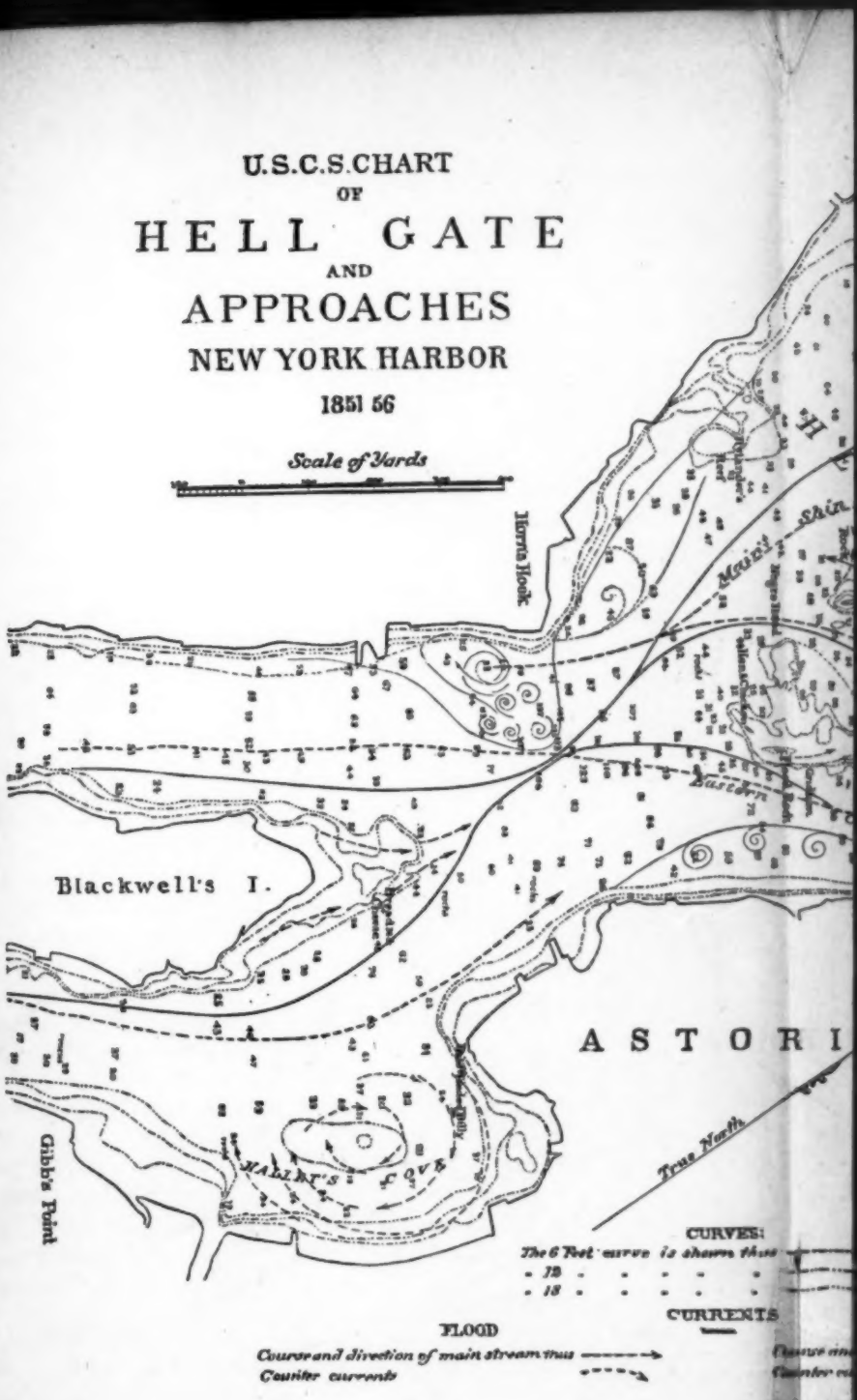
The unobstructed navigation of the East River would also have an important bearing on the question of national defense in case of war with a foreign state. It would render the blockading of the port of New York a task of doubled difficulty, and would open the shores of Long Island to our larger war-vessels and to ironclads.

For these reasons the problem of removing the obstructions to the free and safe passage of vessels through the East River has engaged an increasing degree of attention for a considerable time. These obstructions were all accumulated within a short distance of one another, in the narrow strait called Hell Gate, and were occasioned by numer-

ous reefs of rocks encroaching on the channel and the violent currents to which they give rise, making navigation extremely hazardous for all kinds of vessels.

A clear idea of the nature of these obstructions and dangers in the original condition of the strait is given in the report of Lieutenant-Commanding Davis, who, with Lieutenant-Commanding David Porter, made a survey of the place in 1848. "The strength of the current," he says, "is such that sailing-vessels can only stem its force or escape from it by a commanding breeze; but, as the main course of the flood-tide keeps the middle of the Eastern Channel, it is most secure for vessels which are coming from the westward with the tide to place themselves in the middle of the stream and follow its direction. This plan, however, is inadvisable for any but small vessels, on account of the rocks, the Pot and Frying-Pan, which lie in or very near the mid-channel, are in the way both going to the eastward and westward, and have but little water on them at low tide. There is also a reef called Way's Reef, which lies in the course followed by steamboats principally when coming from the eastward against a strong flood. It is their custom to keep close round Pot Cove, and run up under Hallet's Point, by which they avoid the strength of the flood. In this part they find an eddy-current in their favor. But on the ebb the greatest danger arises from the divergence of the current, when the ebb branches off into three directions to take the course of the three channels—the main Ship-Channel, the Middle Channel, and the Eastern Channel. The safe navigation depends here upon deciding sufficiently soon at the point of separation which channel shall be taken; and the neglect to do this, or a loss of control over the vessel for any reason, frequently results in being carried on the Gridiron. When a vessel that has attempted the Eastern Channel finds herself carried toward the Gridiron, her only chance for safety is to run for the Middle Channel, which is narrow and made precarious by the middle reef, the outer rock of which is the Negro Head. The Gridiron is, owing to the strong set of the tide upon it, the most dangerous reef in the passage. The reef known as Bread and Cheese, on the eastern end of Blackwell's Island, is also very dangerous. Vessels are liable to go on it in the flood, when it is covered, by getting into the eddy near it with a light wind. The chief danger is on the ebb, and from the same reason that makes the Gridiron dangerous—i. e., the strong set of the tide in that direction."

The reefs (see map) known as the Gridiron, Flood Rock, Hen and Chickens, and Negro Head, are all essentially parts of one reef, which is designated as the Middle Reef. Between this reef and the reef which is marked by the projections of the Great and Little Mill Rocks, is situated the Middle Channel. The Eastern Channel is included between the Middle Reef and Hallet's Point. The South or Main Ship Channel lies to the west of Great and Little Mill Rocks, and between


U.S.C.S.CHART
OF
HELL GATE
AND
APPROACHES
NEW YORK HARBOR
1851 56
Scale of Yards
Horns Hook
Blackwell's I.
Gibbs Point
HALLET'S COVE
Pot
True North
CURVES:
The 6 Feet curve is shown thus
12
18
CURRENTS
FLOOD
Course and direction of main stream thus
Counter currents

E
H A R
Main Ship Channel
Middle Ground
Eastern Channel
Fort Stevens
Hallet's Point
ASTORIA
Shell Drake
Point Adams
Peacock Spit
True North
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Fort curve is shown thus
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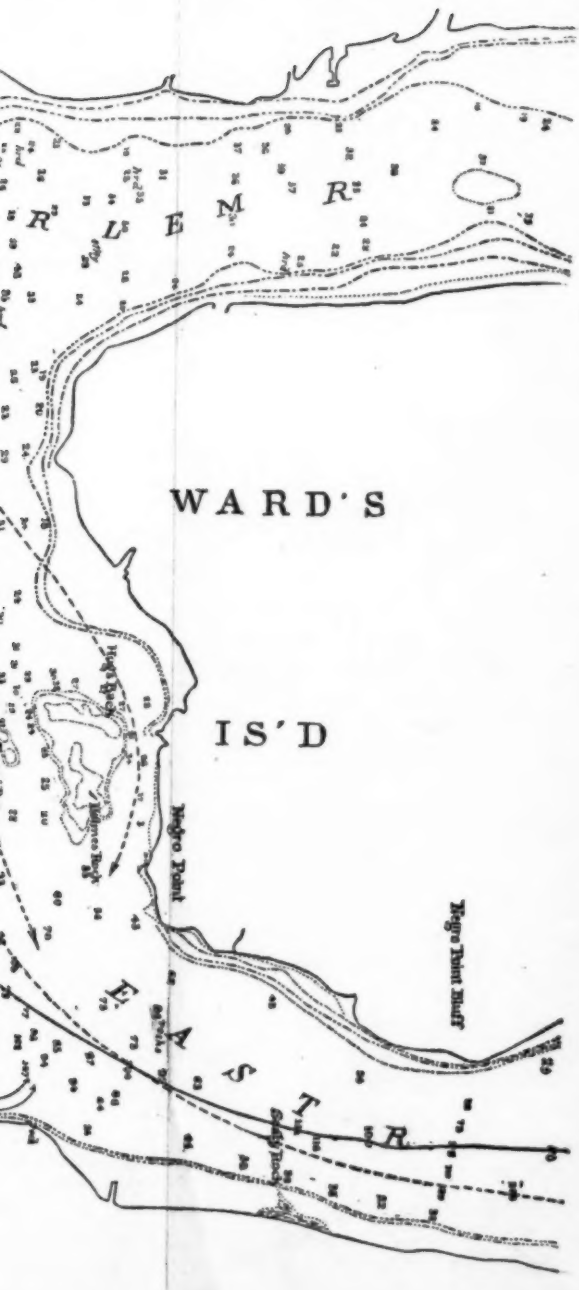
R
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Negro Point
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them and Rhinelander's Reef. The two surveying-officers, while agreeing as to the desirability of removing or mitigating the obstructions, made different recommendations respecting the manner in which they should be dealt with.

Lieutenant-Commanding Davis recommended that Pot Rock, the Frying-Pan, and Way's Reef be blasted and scattered, and that the Middle Channel be improved by blasting, so as to make a clear channel of sufficient depth for common vessels and steamboats. As the removal of the larger reefs seemed at that time impracticable, he advised that they be faced with sea-walls or piers rising four feet above high water, and provided with spring fenders such as are used at the ferry-docks, so adjusted as to guide vessels coming in contact with them into the channel-ways. Lieutenant-Commanding David Porter, not regarding the deepening of the Middle Channel as practicable, advised that it be filled in with docks, and recommended the removal of a part of the reef at Hallet's Point.

No efficient method was suggested for removing the rocks it was proposed to take away, further than to blast them and leave the fragments to lie where they might fall, or to be washed away by the currents. This method would obviously make but a slight impression on the larger reefs.

A process of surface-blasting was first applied by M. Maillefert in 1851. His method consisted simply in placing upon the rock a charge of gunpowder, usually of 125 pounds, contained in a tin canister, and exploding it by means of the voltaic current. The weight of the water resting upon the charge served to increase the effects of the explosion. No means were provided for removing the broken rock except by breaking it up by successive explosions till it was fine enough to be carried away by the currents. M. Maillefert's operations resulted, by the use of 620 charges containing 74,192 pounds of powder, at a cost of $13,861, furnished through Mr. Merriam, in removing from the rocks to which they were applied the projecting prominences of small area, but were of little effect when, after reaching the main rock, a considerable extent of surface had to be dealt with. The depth of water was increased, on Pot Rock, from 8 feet to 18·3 feet; on Frying-Pan, from 9 to 16 feet; on Way's Reef, from 5 to 14 feet; and on Shell Drake, from 8 to 16 feet. Bald-Headed Billy and Hoyt's Rocks were blown into deep water. The depth on Diamond Reef was but slightly if at all affected, and no effect was produced on Hallet's Point Reef. In 1852, Congress having appropriated $20,000 for the removal of obstructions, Major Fraser, by Maillefert's method, increased the depth over Pot Rock to 20·6 feet, adding 2·3 feet of water to the 18·3 Maillefert had gained, with the expenditure of $6,837. The decrease in the ratio of returns for expenditure was occasioned by the increased surface of the rock, due to increase of depth.

In 1856 an advisory council to a commission on the removal of

obstructions in Hell Gate recommended a plan which, as to its general features, was substantially the same as that which Lieutenant-Commanding Davis had proposed in 1848. Instead of Maillefert's process of surface-blasting, they recommended that of drilling. This would have had to be done from within a diving-bell, which was impracticable because of the certain disturbance of the apparatus by currents, and the liability to collisions from passing vessels. All of the plans so far tried or proposed seemed to have been limited to removing the smaller rocks lying in the channel; the possibility of clearing away the larger reefs was not yet conceived.

In 1866 the department instructed me to make an examination of Hell Gate, and to present a plan and estimate of the operations necessary to improve its navigation. A report was submitted in January, 1867, with an estimate for removing the reefs by blasting, after drilling the surface from a fixed platform above the water. In this plan, or in whatever plan might be decided upon, it was considered essential that the drills, which, to avoid interference from currents, were to be worked within iron tubes reaching from the platform to the rock, should be attached to a framing kept absolutely fixed while the drilling was going on; and that the divers or the machinery necessary to handle and remove from the bottom the rock blasted should be protected from violent currents. It was proposed to accomplish the latter object by means of a system of floats and iron curtains so arranged as to constitute a dam protecting a space of 160 feet long and 40 feet wide, within which the work could go on uninterrupted. Another machine was alternatively suggested, embodying the same principle, to consist of an iron caisson or cylinder, pointed at the ends, open at the top and bottom, and having self-adjustable legs to accommodate themselves to the irregularities of the rock, and to support it and keep it level. The top of this structure was to be above the level of the highest tide, and to be framed over so as to form a platform, on which the machinery could be placed, and from which the operations could be conducted. It was important in constructing the machine to have it adaptable to all the rocks on which it was intended to operate, whatever their size and the shape of their surface, and that it be perfectly stable against the action of the currents without being unwieldy in size. It was furthermore considered necessary to furnish it with a protection against collisions which were sure to occur from the fleets of vessels passing daily, and certain to destroy it, with a loss of life and much property, if it were not protected.

These conditions were fulfilled in the steam-drilling cupola-scow (Figs. 1 and 2). The scow is built very heavy and strong; is provided with an overhanging guard, faced with iron, surrounding it as a protection against collisions; and has a well-hole 32 feet in diameter. The caisson or dome is a hemisphere 30 feet in diameter, composed of a strong iron frame covered with boiler-iron. It is open at the bottom

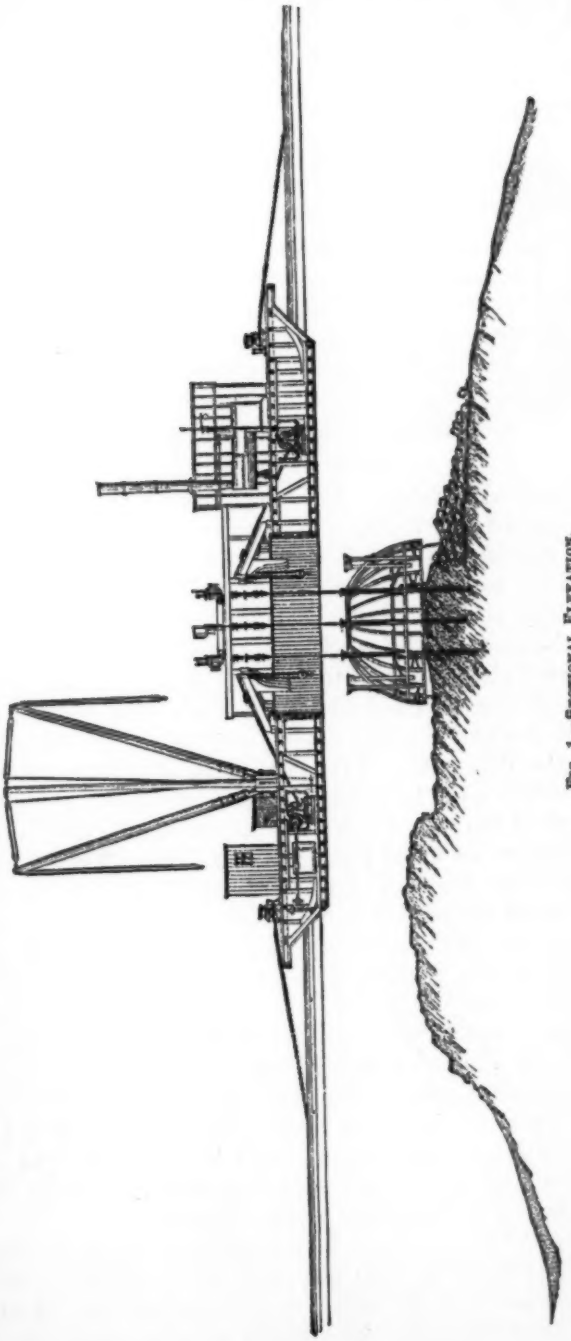


FIG. 1.—SECTIONAL ELEVATION.

and top, and is provided with self-adjustable legs so arranged as to be all let go together after it is lowered. This caisson or dome is simply a framework affording a fixed support to the drill-tubes, twenty-one in number, through which the drills operate. It is connected with the scow by four chains, communicating with four hoisting-engines, by

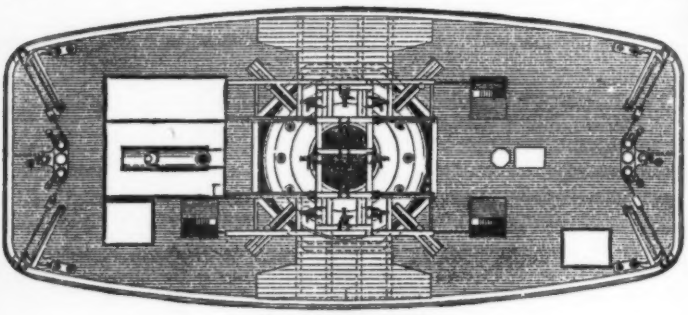


FIG. 2.—DECK PLAN.

which it is lowered or raised. The scow, having the dome swung by chains, is anchored over the rock to be operated upon, by as many anchors as are required to hold it against all the currents. The diver then goes down to examine the bottom and see that the position is favorable. The position of the scow is changed by lengthening and shortening the moving chains with capstans. When all is fixed, the dome is lowered close to the bottom and established by letting the legs go to adjust themselves on the bottom. The chains which connect it with the scow are unslung, and flexible connections are made between the tops of the drill-rods and the piston-rods of the driving-engines. These connections must be flexible, because, the dome being fixed on the bottom, while the scow holding the drill-engines is certain to swing for short distances back and forth, the connections, if rigid, would be broken. When the drill-holes are completed and ready to be charged, the dome is lifted up, and the scow, carrying the suspended dome, is swung off from the spot to a safe distance (the length of which depends on the amount of the charge), without casting loose the moorings. The charges of explosives, in tin cases of different lengths to suit the varying depths of the drill-holes, are carried to the spot upon a small scow, whence the diver descends to insert them into the holes; the cartridges are handed down to him, already attached to leading wires by the men on the scow; and he is guided from hole to hole by lines connecting the stoppers or plugs inserted in the holes. The scow is withdrawn, the leading wires are connected with the battery, and the explosion is made with invariably certain effects.

To secure satisfactory results in the breaking up of the rock, the drill-holes should be six or eight feet apart, five to six inches in diameter, and should reach to about four feet below the level to which it is desired to break the rock. The broken rock is removed by means

of a steam-grapple. Provision was made for the attachment of curtains, or dams, of chain-netting, rope-netting, or canvas, to the bottom of the dome and to the steam-grappling apparatus, as a shield against currents, but it was not found necessary to use anything of the kind.

Operations with the steam-drilling scow were completed January, 1880, upon Diamond Reef. The rock was covered with a large accumulation of loose material which had first to be removed with a dredging-machine, after which all of the ledge that was uncovered was attacked. The holes were drilled from seven to thirteen feet deep, four and a half inches in diameter at the top, and three and a half inches at the bottom, and were charged with from 30 to 55 pounds each of nitro-glycerine.

Coenties Reef was worked upon in alternation with Diamond Reef in 1871 and completed in 1875.

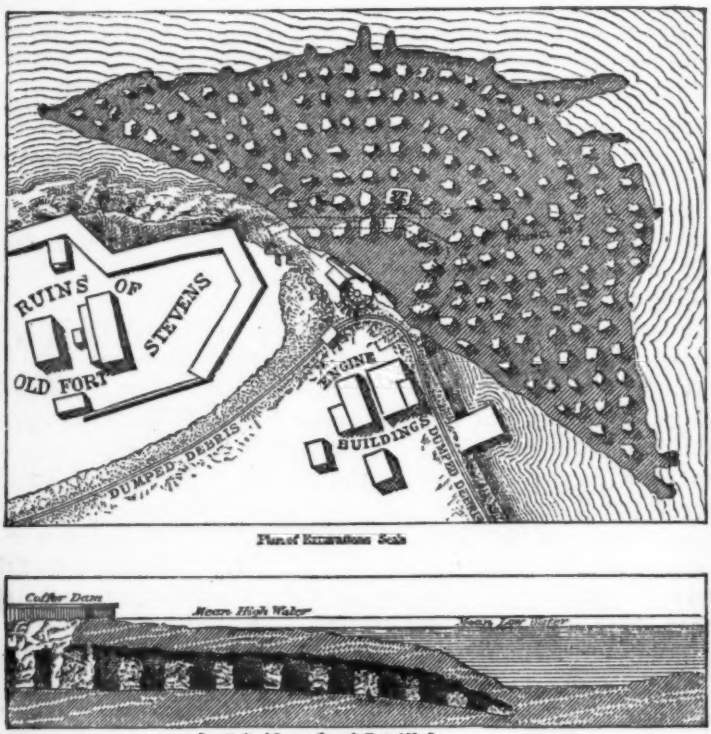
In 1872 work was commenced on Frying-Pan, and there is now twenty-two feet at low water.

Work was prosecuted on Pot Rock in Hell Gate from August 5 till December 28, 1872, during which period the scow was much exposed to collisions, of which sixteen took place. In one of them the colliding vessel was drawn under the scow and carried off the dome, which was afterward recovered, considerably damaged, in eighty feet of water. The depth on this rock is now twenty-four feet.

Way's Reef, over which the original depth of water was five feet, having already been cleared by the application of M. Maillefert's process of surface-blasting in 1851 and again in 1869, to 17½ feet, was operated upon from August 4, 1874, to January 20, 1875, and the depth of water was increased to 26 feet at low water. The rock within the 26-feet curve measured 235 feet in length by 115 feet of maximum width. To accomplish the result two hundred and sixty-two holes were drilled to an aggregate depth of 2,130·4 feet, sixty-five drill-blasts and sixteen surface-blasts were made, and 16,792¾ pounds of nitro-glycerine and 38½ pounds of dynamite were consumed.

For the removal of Hallet's Point Reef it was determined to employ a process of undermining the rock by tunnels and galleries, from which mines should be exploded to break up the whole mass of the rock at once. Similar processes had already been suggested by General Alexander, United States Engineers, and A. W. von Schmidt, C. E., for the removal of Blossom Rock, in San Francisco Harbor. The reef in question (Fig. 3) was in the shape of a semi-ellipse, extending 720 feet in length along the shore, and to a distance of 300 feet in breadth into the channel; and the cubic contents necessary to be removed, in order to secure a depth of 26 feet at mean low water, amounted to 53,971 cubic yards. The reef was dangerous, not only in itself, but also on account of the eddies to which the tidal currents gave rise on either side of it, according to their direction. Opera-

tions were begun here in July, 1869, for the construction of a coffer-dam between high and low water marks; and in the following October the excavation of a shaft, conforming in shape to that of the dam, and 32 feet in depth, was begun. Thence tunnels radiating through the rock, with transverse galleries, 25 feet apart, to connect them, were excavated till thirty-five tunnels and ten galleries were constructed, having an aggregate length of 7,426 feet. The tunnels were from 17 to 22 feet high and from 9 to 12¾ feet wide at the shaft, and tapered off in both dimensions as they went out; and the galleries were from 12 feet high by 9 feet wide down to smaller dimensions.



Plan of Excavations &c.

Longitudinal Section through Tunnel No 7.

FIG. 3.—HALLET'S POINT.

The work of excavation was commenced in the latter part of October, 1869, and terminated in June, 1875. Deducting the time lost by suspension of work due to the exhaustion of current appropriations, the actual period consumed in this work was four years and four months. The appropriations were, under the law, devoted to many reefs in the East River and Hell Gate besides the one at Hallet's Point; the result being that the work was rarely prosecuted in full force at the latter place. With a more generous grant of money the time consumed until the explosion, which amounted in all to six years and ten months, could have been reduced to four years.

As soon as the excavation was finished, the work of drilling holes in the roof and piers, to be afterward charged with explosives, was begun. At the completion, March 25, 1876, there had been drilled in the roof 5,375 three-inch, in the piers 1,080 three-inch, and 286 two-inch holes; the total length of holes drilled being 56,548 feet of three-inch and 1,897 feet of two-inch holes.

The proximity of the reef to habitations at Astoria, Ward's Island, and Blackwell's Island, made it necessary to devise a system of explosion which, effecting the work of demolition, would at the same time do no damage to life and property. The atmosphere and the rock being the mediums through which the shock would be transmitted, it was essential that the waves propagated through these should be as small as possible.

It was evident, in the first place that, if to each charge its full capacity of useful work in breaking up the rock was assigned, regard being likewise had to the superincumbent weight of water, no external effect of moment would be perceived in the atmosphere. In the second place, it was evident that the magnitude of the rock-wave would depend greatly upon the quantity contained in individual charges, that is, if eighty pounds were required for the individual charge, the vibration of the rock would be much greater than if these charges did not exceed twenty pounds. It was known that eighty-pound charges of nitro-glycerine, fired in numbers of twelve to twenty, did not cause a destructive wave. Again, the reef, after the excavation, being connected with the rock only through the piers and outer edge of the roof, it was inferred that the shock propagated in the rock would be due mainly to the charges necessary to disrupt the piers and roof from their connection with the bed-rock, and not to the charges to break up the roof and piers. The cubic contents of the roof and piers were 63,135 cubic yards, and the amount of explosives—

Rend-rock	9,127	pounds
Vulcan powder	11,853	"
Dynamite	28,935	"
Total	49,915	

Being at the rate of 0·79 pound to each cubic yard.

The explosives were placed in tin cartridge-cases. The number used was 13,596, 87 per cent being 22 inches and the remainder 11 inches in length. The number of holes charged was 4,427.

The system consisted of 3,680 mines and 23 batteries. Each battery assigned to 160 mines, which were divided into eight groups of twenty each. The mines of each group were connected in continuous series, and a lead and return wire to the battery closed the circuit.

The mines were fired at two hours fifty minutes P. M., September 24, 1876, and there were no injurious shocks in the atmosphere, in the water or underground.

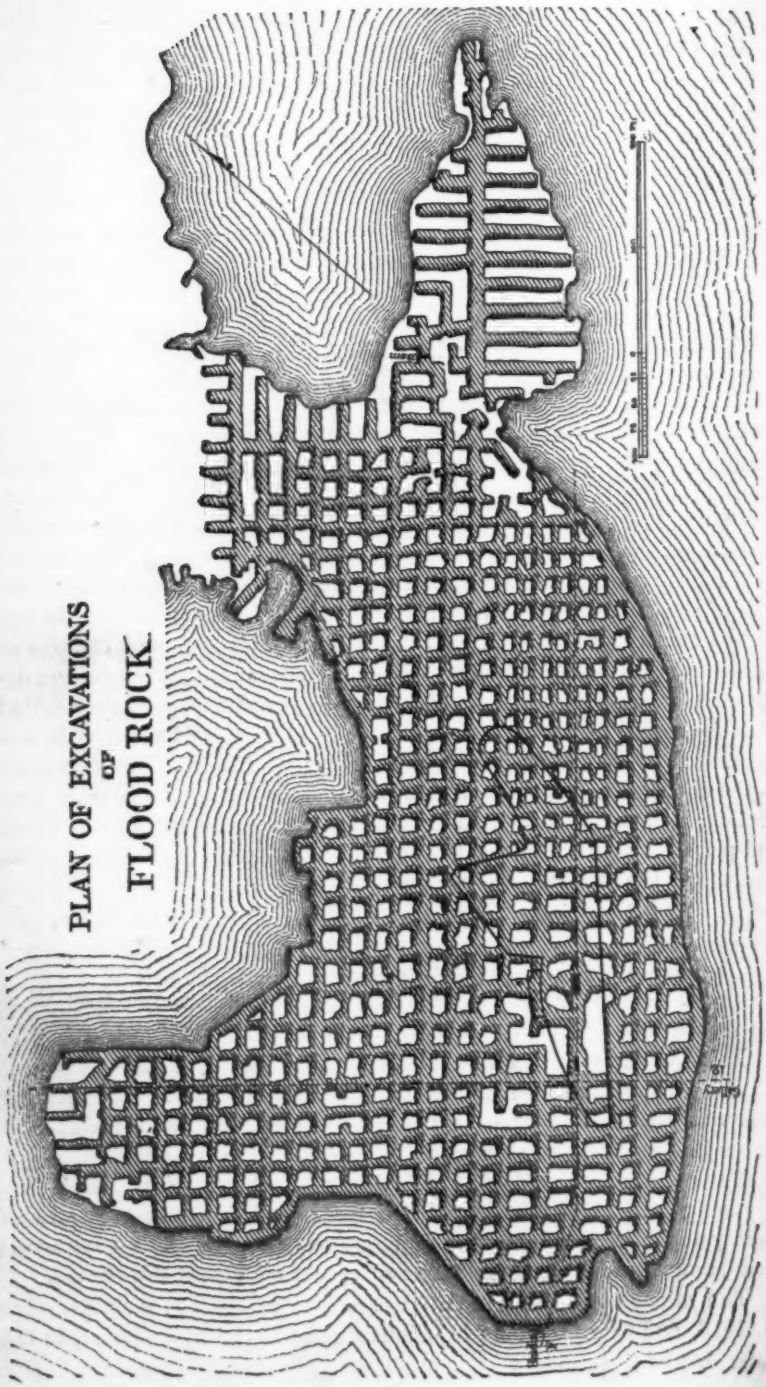


FIG. 4.

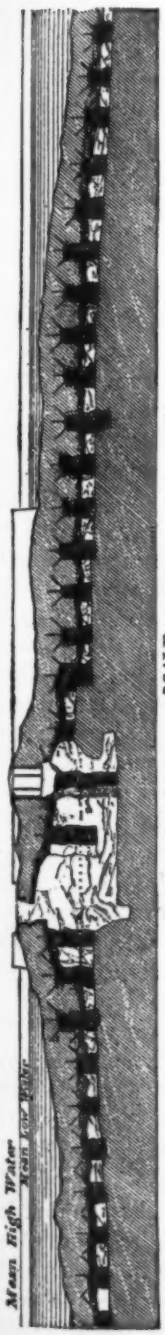


FIG. 5.—SECTION THROUGH HEADING F.

FIG. 6.—SECTION THROUGH GALLERY 12.

The new facts obtained by this experience are:

1. That an unlimited amount of explosives distributed in blast-holes in moderate charges, proportioned to the work to be done, thoroughly confined in the rock, and tamped with water, may be fired without damage to surrounding objects.

2. That an unlimited number of mines may be simultaneously fired by passing electric currents through the platinum-wire bridges of detonators.

Substantially the same methods as those which had proved efficient upon the Hallet's Point Reef were applied to the larger and more formidable Flood Rock. Two shafts were sunk from the ridge of the rock (Fig. 4), whence the whole nine acres of the reef—extending 1,200 feet in length and 602 feet in width—was undermined by two sets of parallel galleries, running at right angles to one another. The piers of rock left between these galleries to support the roof of the mine were about fifteen feet square and twenty-five feet apart from center to center. The roof of the cross-galleries, which ran at right angles to the lines of stratification, was blasted down as thin as it would be safe to leave it (Figs. 5 and 6). Considerable risk was incurred in this part of the work, from the danger of the rock crumbling, and from the uneven and uncertain thickness of the roof. The average thickness was 18·8 thick, and the minimum thickness ten feet. The exact thickness could not be ascertained beforehand, for no

soundings could distinguish between the solid rock and a concretion of bowlders and shells formed upon it. Had the excavations at any time broken into a large seam, the mine would have been flooded by the inrush of the water, and all the work and probably many lives would have been lost. Occasionally small seams were met and had to be dealt with. One seam was ten inches wide and a hundred feet long; another one, from one to four inches wide and 400 feet long, extending clear across the reef, carried 350 gallons of water a minute. The latter was dealt with after protecting the completed part of the work by building across the gallery a door capable of withstanding the pressure of the water. The seams were all walled, as fast as they were opened, with Portland cement. The total length of the galleries was 21,670 feet.

The galleries were excavated to depths varying with the uneven surface of the reef. The roof was then drilled with holes for the reception of the explosive cartridges, with which the rock was to be finally blown up. The holes were slanted upward at angles varying from 75° to 45°, and were made from eight to ten feet deep—except where the existence of seams open to the river made it impossible to obtain the depth wanted—and of sufficient capacity to receive a rigid two-and-a-half-inch cartridge throughout their entire length.

The holes were charged with rack-a-rock as the principal explosive—a substance formed by mixing 79 parts of finely-ground chlorate of potash and 21 parts of di-nitrobenzole. It is one of the safest explosives to handle, and the ingredients are absolutely inert when kept separate, and they need not be mixed till just before loading the cartridge; it has $109\frac{3}{16}$ per cent the strength of No. 1 dynamite, when fired under water, and costs but a little more than half as much. The mixing was done in small batches on Great Mill Rock, in a lead-lined trough, and the explosive was packed at once into cartridge-cases $2\frac{1}{4}$ inches in diameter and 24 inches long, made of copper 0·005 of an inch thick. To prevent the corrosion of the copper by the chemical action of the sulphureted water running through some of the drill-holes, the cartridges were protected by being dipped in melted resin, beeswax, and tallow. The cartridges, after being loaded, were soldered with a steam-heated soldering-iron; were removed as fast as they were filled, and were carried to the mine in boxes containing twenty each; so that the amount of mixed explosive above-ground at any one time was never enough to do more than local damage in case of an accident. These cartridges were inserted in the drill-holes, one after the other, till the holes were filled, the last cartridge in every case being filled with dynamite, with its end left to project about six inches, so that it might receive the full effect of the shock from the initial charges connected with the battery. This cartridge is represented in Fig. 7, and is 15 inches long and $2\frac{1}{4}$ inches in diameter. In its forward or projecting end is inserted a small copper shell filled with fulminate of mercury. The other cartridges, charged with rack-a-rock, repre-

sented in Fig. 8, are 24 inches long by 2¼ inches in diameter, and are provided at their forward ends with a fulminate primer which is inserted after they are filled. This primer is shown in half size in Fig. 9, and consists of a fulminate exploder similar to that shown in Fig. 7, in a copper tube containing an ounce of No. 1 dynamite. The

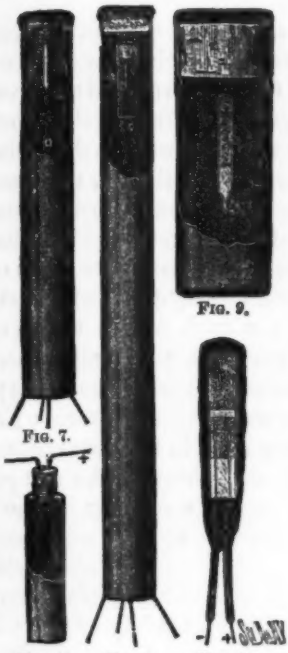


Fig. 11. Fig. 8. Fig. 10.
Cartridges and Mine-Exploder.

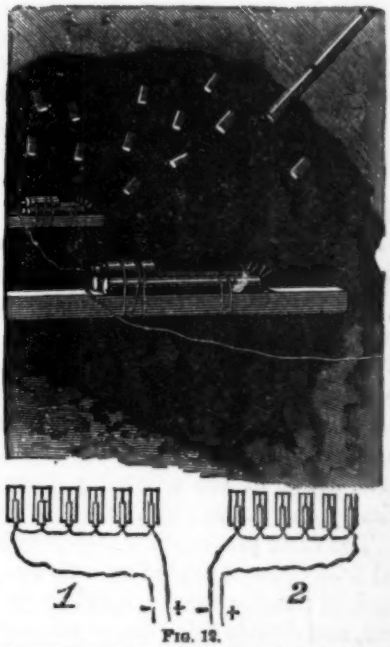


Fig. 12.
Arrangement of the Charges in the Mines.

cartridges are secured in the holes by the wire springs shown at their lower ends; and the dynamite cartridge is also wedged in with wooden wedges. Fig. 10 shows the mine-exploder, the position of which in the mine is illustrated in Fig. 12. It consists of a brass cylinder, eight inches long by two in diameter, filled with dynamite. Inclosed within the dynamite is a fuse, shown half size in Fig. 10, the wires from which pass through a divided cork in the mouth of the brass cylinder. It consists of a copper tube nearly filled with 30 grains of fulminate of mercury. Fitting in the open end of this tube is a second tube containing sulphur, through which pass the two conducting-wires, they being held firmly in place by the sulphur. The inner ends of the wires are united by a small platinum wire. The ends of the wires are then surrounded with fulminate, and the two parts of the tube are put together, that containing the wires slipping within the other. The entire fuse is then covered with gutta-percha. The passage of an electric current through the wires heats the platinum bridge to redness, and causes an explosion of the fulminate.

The number of pounds of rack-a-rock put into drill-holes was 240,399; of dynamite, 42,331; total, 282,730 pounds. There were 11,789 drill-holes in the roof and 772 in the pillars, and their total length was 113,102 feet, or more than twenty miles. The whole amount of rock to be broken by the final blast was 270,717 cubic yards, covering an area of about nine acres.

The primary charges, the office of which was by their detonation to produce the explosion of the charges in the drill-holes, were placed along the galleries at intervals of twenty-five feet, and arranged as shown in Fig. 12. They were placed on timbers extending from wall to wall in each of the galleries, and consisted of two twenty-four-inch dynamite cartridges like those already described lashed to the timber, with one of the "mine-exploders," also already described, bound upon them. The entire mine was divided into twenty-four independent circuits. Within each of twenty-one of these circuits were twenty-five fuses or mine-exploders, while three circuits contained twenty-two fuses each. A wire from the battery on the surface of the rock at the mouth of the shaft led from one fuse to the next, until the twenty-five fuses were in the same electrical circuit, and thence back to the battery. So far as was practicable, adjacent charges were put on different circuits, so that if any circuit failed through any fault in the connections, an explosion of its charges would still be insured through the sympathetic action of the adjoining charges. The whole number of these primary charges was 591. Some of the circuits were nearly a mile long.

The fuses prepared for this work had a resistance of 1·73 ohms cold, and 2·76 ohms at explosion. To fire a single fuse, 0·205 ampères were required; to fire a series, 0·615 ampères. A factor of safety of two was used, and double this current was sent through every fuse at the final blast. The battery consisted of sixty cells, all coupled in one series, each of which had an electro-motive force of 1·95 volts and an internal resistance of 0·01 ohms. The plates were six inches by nine inches—four carbon and three zinc plates in each cell, separated by a quarter of an inch. The ordinary bichromate solution was used. The poles were constituted of two large mercury-cups, into one of which were dipped the twenty-four lead-wires, while the twenty-four return wires terminated in a third cup. Between this third cup and the remaining pole of the battery stood the apparatus for closing the circuit. It consisted of a stout iron cup containing mercury, in which sat a thin glass tumbler also partly filled with mercury. Two large strips of copper connected the mercury in the iron cup with one pole of the battery, and that in the glass with the cup containing the return wires. To close the circuit through the fuses it was only necessary to break the tumbler so as to let the mercury in it mix with that in the iron cup. To do this at the proper moment, a one-quarter-inch iron rod four feet long, terminating at the top in a small round disk, stood with its point in the bottom of the glass. It was long enough

to pass through the roof of the battery-house. A thirty-grain platinum fuse, connected with a small battery at Astoria, was laid on the disk and stuck on with a lump of wax. It had been previously determined by experiment that the blow struck by this fuse on exploding, and transmitted by the iron rod, would be so sharp as to completely pulverize the tumbler and yet not splash the mercury.

The mine was flooded by two siphons of twelve and sixteen inches respectively, in fifteen hours and a half, ending at 3.30 A. M., October 10th. The explosion was set for 11 A. M., October 10th, but the interests at stake were so great, and the details to be looked after to avoid every chance of miscarriage so numerous, that, in spite of the most energetic effort, everything could not be made ready and *tested* in time to fire at the appointed moment. The explosion did not actually take place till 11.13. This delay caused some confusion in the seismoscopic observations.

The whole area of the reef was shattered. The plan of making the excavations large enough to swallow all the *débris* of the reef and leave a channel deep enough, without further operations, already abandoned at Hallet's Point as more expensive than dredging up the broken rock, was never entertained at Flood Rock. Hence the sensational view, which many persons expected to witness, of a sudden disappearance of the rock, was not seen. Though the charges all exploded at the same instant, the time and the appearance of the effect above the water-surface varied according to the strength of the rock and the depth of the water. There was no loud report and no dangerous shock. The breaking of some panes of glass and the shaking down of a few bricks and loose ceilings constituted all the damage that was done.

Pending the awarding of a contract for dredging, the work of removing the rock was begun with a scow belonging to the Government as soon after the explosion as possible. From fifteen to thirty tons of rock were removed daily by being hoisted out after having been slung by divers on chains. A contract has been let for the removal of 30,000 tons of the rock at $3.19 per ton, the contractor to do his own surface-blasting. This is less than the price for which rock was removed on similar terms at Hallet's Point. The contractor has two grapples at work, and is removing an average of about 120 tons a day. As a whole, the cost of mining a cubic yard of rock has been reduced 34⅔ per cent from the cost of doing the same work at Hallet's Point. The total cost of the work done on Flood Rock, including the final blast, amounts to $2.99 per cubic yard of the whole amount of rock broken, or $5.66 less than the cost of breaking Hallet's Point. A considerable part of this gain will, however, be expended on the proportionately larger amount of dredging to be done. The net result, however, will show an improvement of not less than 30 per cent, and probably more. The total cost of the final blast at

Hallet's Point was $81,092.24; at Flood Rock it was only $106,509.93, though the blast was 5·6 times as large. These results together indicate that a great advance has been gained in the economy with which the whole work was carried on; and the progress with the dredging gives promise that an 18-foot channel, 400 feet wide, over the worst part of the reef, may be cleared out by spring. If the funds are supplied as needed, the dredging can all be completed in three years.

The accounts of the observations of the shock of the explosion, have been tabulated by General Abbott, as follows:

STATION.	Distance in miles.	Interval of transmission.	Velocity in miles per second.
West Point, N. Y.	42·34	10·9	3·88
Hamilton College, N. Y.	....	45·0	3·88
Pearsall's, L. I.	16·78	6·6	2·54
Bay Shore, L. I.	36·65	13·0	2·82
Patchogue, L. I.	48·52	15·4	3·15
Goat Island, R. I.	144·89	58·8	2·46
Harvard Observatory, Cambridge, Mass.	182·68	19·8	0·83
Princeton, N. J.	48	251·0	0·94

It seems that the speed of the oscillation-wave is the greatest through an uninterrupted rock formation.

Fig. 13 is a bird's-eye view of the reefs of Hell Gate, taken from a model constructed from the preceding map and from surveys of the Engineer Department. The white margin around the shores and reefs represents the parts between mean low water and twenty-six feet below it, the level to which all reefs obstructing navigation are to be reduced.

Negro Point (1): on this reef no work has been done. It is to be undermined and cut off on a line with the Sound-entrance wharf. Holmes Rock (2) and Hog-Back (3) are simply to be finished with a sea-wall. Frying-Pan (4) has been reduced to the level of twenty-four feet below mean low water. Way's Reef (6), Shell Drake (7), finished to the full depth of twenty-six feet. Hallet's Point (8), the rock shattered by the explosion has been entirely removed to the depth of twenty-six feet. The projecting point has been cut off, as shown by Fig. 3. Heel-Tap (9), broken to twenty-six feet, dredged to twenty-two feet, to be cleaned to full depth. Great Mill Rock (10), Little Mill Rock (11), connected by a dike; nothing further to be done here. The Gridiron (12), Flood Rock (13), Hen and Chickens (14), Negro Heads (15), broken to thirty feet; 15 is now being removed to open the Middle Channel at once, and the balance afterward to full depth. Rylander's Reef (16) to be embanked. Bread and Cheese (17) has already been embanked. Scaly Rock (18) has been removed.

It will be readily understood from the above description what has been contemplated by these improvements, how far they have already been carried out and what purpose they have served, and how adequate will be the channel after they are completed.

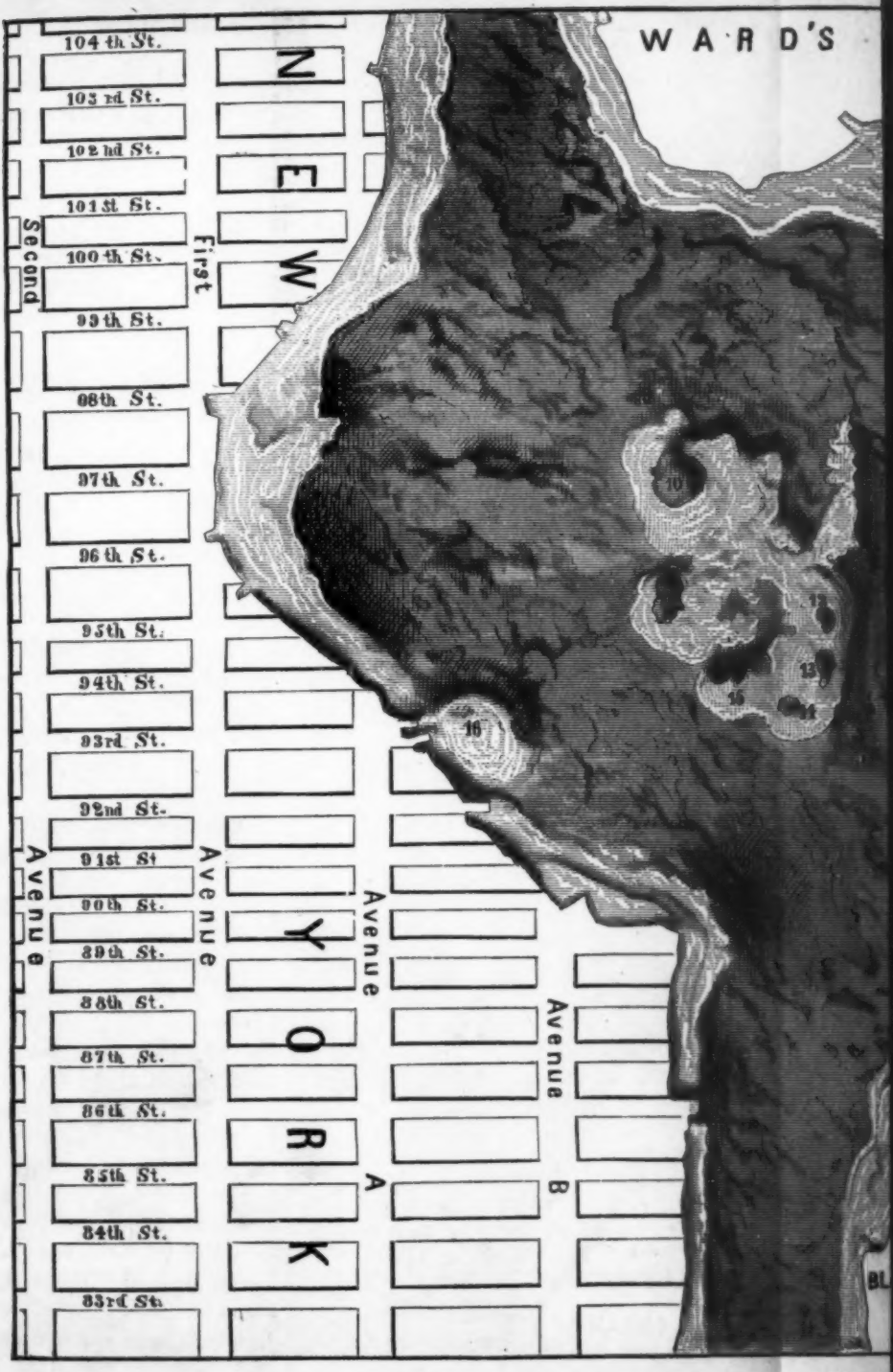
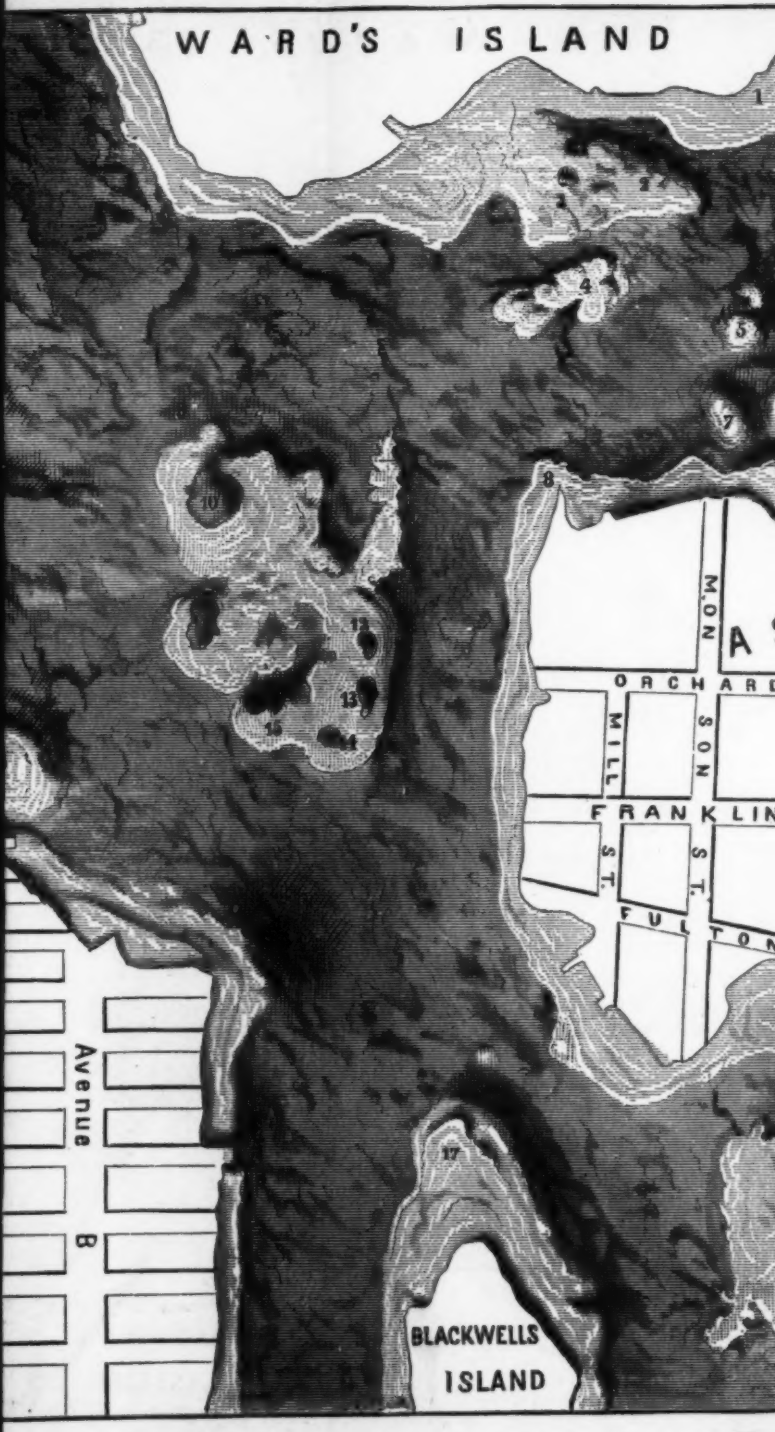
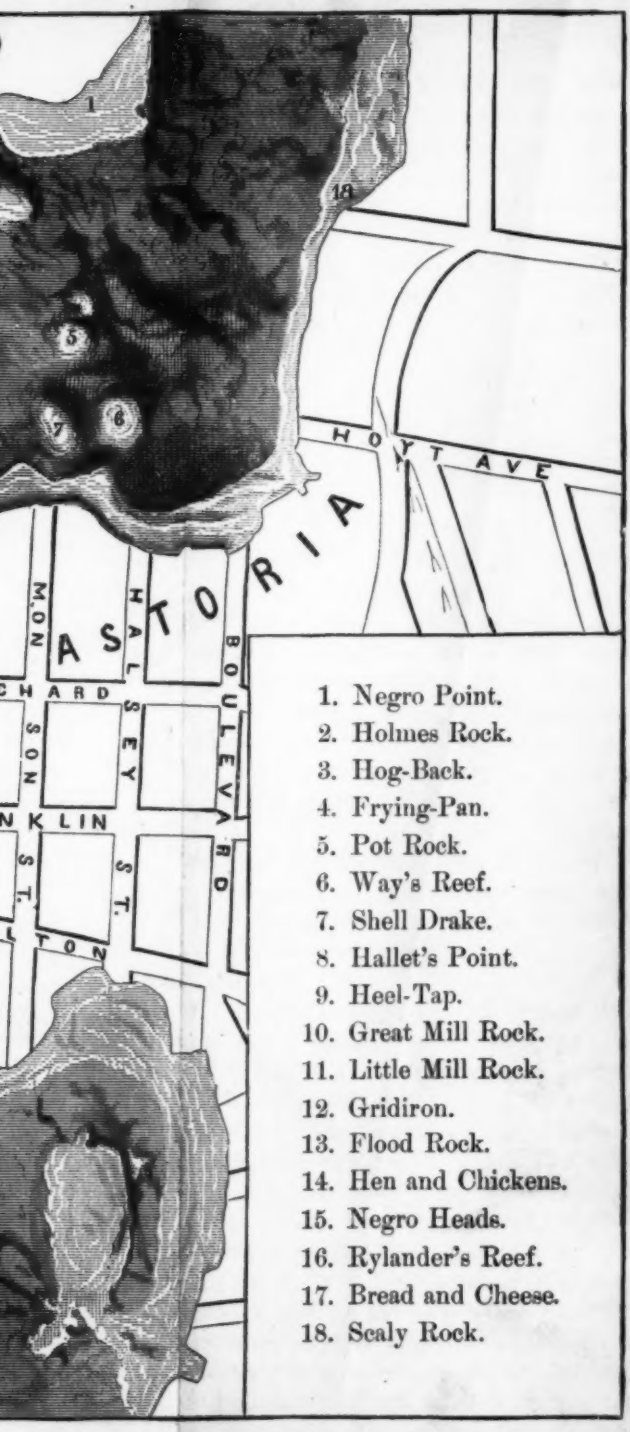


FIG. 13.—BIRD'S-EYE VIEW OF THE RIVE



13.—Bird's-eye View of the River-bottom and Reefs at Hel



1. Negro Point.
2. Holmes Rock.
3. Hog-Back.
4. Frying-Pan.
5. Pot Rock.
6. Way's Reef.
7. Shell Drake.
8. Hallet's Point.
9. Heel-Tap.
10. Great Mill Rock.
11. Little Mill Rock.
12. Gridiron.
13. Flood Rock.
14. Hen and Chickens.
15. Negro Heads.
16. Rylander's Reef.
17. Bread and Cheese.
18. Scaly Rock.

s at Hell Gate.

THE INTERPRETERS OF GENESIS AND THE INTERPRETERS OF NATURE.

By Professor T. H. HUXLEY.

OUR fabulist warns "those who in quarrels interpose" of the fate which is probably in store for them; and, in venturing to place myself between so powerful a controversialist as Mr. Gladstone and the eminent divine whom he assaults with such vigor in the last number of this review, I am fully aware that I run great danger of verifying Gay's prediction. Moreover, it is quite possible that my zeal in offering aid to a combatant so extremely well able to take care of himself as M. Réville may be thought to savor of indiscretion.

Two considerations, however, have led me to face the double risk. The one is that though, in my judgment, M. Réville is wholly in the right in that part of the controversy to which I propose to restrict my observations, nevertheless, he, as a foreigner, has very little chance of making the truth prevail with Englishmen against the authority and the dialectic skill of the greatest master of persuasive rhetoric among English-speaking men of our time. As the Queen's proctor intervenes, in certain cases, between two litigants in the interests of justice, so it may be permitted me to interpose as a sort of uncommissioned science proctor. My second excuse for my meddlesomeness is, that important questions of natural science—respecting which neither of the combatants professes to speak as an expert—are involved in the controversy; and I think it is desirable that the public should know what it is that natural science really has to say on these topics, to the best belief of one who has been a diligent student of natural science for the last forty years.

The original "Prolégomènes de l'histoire des Religions" has not come in my way; but I have read the translation of M. Réville's work, published in England under the auspices of Professor Max Müller, with very great interest. It puts more fairly and clearly than any book previously known to me the view which a man of strong religious feelings, but at the same time possessing the information and the reasoning power which enable him to estimate the strength of scientific methods of inquiry and the weight of scientific truth, may be expected to take of the relation between science and religion.

In the chapter on "The Primitive Revelation" the scientific worth of the account of the Creation given in the Book of Genesis is estimated in terms which are as unquestionably respectful as, in my judgment, they are just; and, at the end of the chapter on "Primitive Tradition," M. Réville appraises the value of pentateuchal anthropology in a way which I should have thought sure of enlisting the assent

of all competent judges, even if it were extended to the whole of the cosmogony and biology of Genesis:

As, however, the original traditions of nations sprang up in an epoch less remote than our own from the primitive life, it is indispensable to consult them, to compare them, and to associate them with other sources of information which are available. From this point of view, the traditions recorded in Genesis possess, in addition to their own peculiar charm, a value of the highest order; but we can not ultimately see in them more than a venerable fragment, well deserving attention, of the great genesis of mankind.

Mr. Gladstone is of a different mind. He dissents from M. Réville's views respecting the proper estimation of the pentateuchal traditions no less than he does from his interpretation of those Homeric myths which have been the object of his own special study. In the latter case, Mr. Gladstone tells M. Réville that he is wrong on his own authority, to which, in such a matter, all will pay due respect: in the former, he affirms himself to be "wholly destitute of that kind of knowledge which carries authority," and his rebuke is administered in the name and by the authority of natural science.

An air of magisterial gravity hangs about the following passage:

But the question is not here of a lofty poem, or a skillfully constructed narrative: it is whether natural science, in the patient exercise of its high calling to examine facts, finds that the works of God cry out against what we have fondly believed to be his word and tell another tale; or whether, in this nineteenth century of Christian progress, it substantially echoes back the majestic sound, which, before it existed as a pursuit, went forth into all lands.

First, looking largely at the latter portion of the narrative, which describes the creation of living organisms, and waiving details, on some of which (as in verse 24) the Septuagint seems to vary from the Hebrew, there is a grand fourfold division, set forth in an orderly succession of times, as follows: on the fifth day—

1. The water-population;
2. The air-population;

and, on the sixth day,

3. The land-population of animals;
4. The land-population consummated in man.

Now this same fourfold order is understood to have been so affirmed in our time by natural science, that it may be taken as a demonstrated conclusion and established fact (p. 696).

"Understood"! By whom? I can not bring myself to imagine that Mr. Gladstone has made so solemn and authoritative a statement on a matter of this importance without due inquiry—without being able to found himself upon recognized scientific authority. But I wish he had thought fit to name the source from which he has derived his information, as, in that case, I could have dealt with his authority, and I should have thereby escaped the appearance of making an attack on Mr. Gladstone himself, which is in every way distasteful to me.

For I can meet the statement in the last paragraph of the above citation with nothing but a direct negative. If I know anything at all about the results attained by the natural science of our time, it is "a demonstrated conclusion and established fact" that the "four-fold order" given by Mr. Gladstone is not that in which the evidence at our disposal tends to show that the water, air, and land populations of the globe have made their appearance.

Perhaps I may be told that Mr. Gladstone does give his authority —that he cites Cuvier, Sir John Herschel, and Dr. Whewell in support of his case. If that has been Mr. Gladstone's intention in mentioning these eminent names, I may remark that, on this particular question, the only relevant authority is that of Cuvier. But, great as Cuvier was, it is to be remembered that, as Mr. Gladstone incidentally remarks, he can not now be called a recent authority. In fact, he has been dead more than half a century, and the paleontology of our day is related to that of his very much as the geography of the sixteenth century is related to that of the fourteenth. Since 1832, when Cuvier died, not only a new world, but new worlds, of ancient life have been discovered; and those who have most faithfully carried on the work of the chief founder of paleontology have done most to invalidate the essentially negative grounds of his speculative adherence to tradition.

If Mr. Gladstone's latest information on these matters is derived from the famous discourse prefixed to the "Ossemens Fossiles," I can understand the position he has taken up; if he has ever opened a respectable modern manual of paleontology or geology, I can not. For the facts which demolish his whole argument are of the commonest notoriety. But, before proceeding to consider the evidence for this assertion, we must be clear about the meaning of the phraseology employed.

I apprehend that when Mr. Gladstone uses the term "water-population" he means those animals which, in Genesis i, 21 (revised version), are spoken of as "the great sea-monsters and every living creature that moveth, which the waters brought forth abundantly, after their kind." And I presume that it will be agreed that whales and porpoises, sea-fishes, and the innumerable hosts of marine invertebrated animals, are meant thereby. So "air-population" must be the equivalent of "fowl," in verse 20, and "every winged fowl after its kind," verse 21. I suppose I may take it for granted that by "fowl" we have here to understand birds—at any rate primarily. Secondarily, it may be that the bats, and the extinct pterodactyls, which were flying reptiles, come under the same head. But, whether all insects are "creeping things" of the land-population, or whether flying insects are to be included under the denomination of "winged fowl," is a point for the decision of Hebrew exegetes. Lastly, I suppose I may assume that "land-population" signifies "the cattle" and "the beast of the earth," and "every creeping thing that creepeth upon the earth," in

verses 25 and 26; presumably, it comprehends all kinds of terrestrial animals, vertebrate and invertebrate, except such as may be comprised under the head of the "air-population."

Now what I want to make clear is this: that if the terms "water-population," "air-population," and "land-population," are understood in the senses here defined, natural science has nothing to say in favor of the proposition that they succeeded one another in the order given by Mr. Gladstone; but that, on the contrary, all the evidence we possess goes to prove that they did not. Whence it will follow that, if Mr. Gladstone has interpreted Genesis rightly (on which point I am most anxious to be understood to offer no opinion), that interpretation is wholly irreconcilable with the conclusions at present accepted by the interpreters of Nature—with everything that can be called "a demonstrated conclusion and established fact" of natural science. And be it observed that I am not here dealing with a question of speculation, but with a question of fact.

Either the geological record is sufficiently complete to afford us a means of determining the order in which animals have made their appearance on the globe, or it is not. If it is, the determination of that order is little more than a mere matter of observation; if it is not, then natural science neither affirms nor refutes the "fourfold order," but is simply silent.

The series of the fossiliferous deposits, which contain the remains of the animals which have lived on the earth in past ages of its history, and which can alone afford the evidence required by natural science of the order of appearance of their different species, may be grouped in the manner shown in the left-hand column of the following table, the oldest being at the bottom:

Formations.	First known appearance of
Quaternary.	
Pliocene.	
Miocene.	
Eocene	Vertebrate *air*-population (bats).
Cretaceous.	
Jurassic	Vertebrate *air*-population (birds and pterodactyls).
Triassic.	
Upper Palæozoic.	
Middle Palæozoic	Vertebrate *land*-population (amphibia, reptilia [N]).
Lower Palæozoic.	
Silurian	Vertebrate *water*-population (fishes).
	Invertebrate *air*- and *land*-population (flying insects and scorpions).
Cambrian	Invertebrate *water*-population (much earlier, if *Eozoön* is animal).

In the right-hand column I have noted the group of strata in which, according to our present information, the *land*, *air*, and *water* populations respectively appear for the first time; and, in consequence of the ambiguity about the meaning of "fowl," I have separately indicated the first appearance of bats, birds, flying reptiles, and flying insects. It

will be observed that, if "fowl" means only "bird," or at most flying vertebrate, then the first certain evidence of the latter, in the Jurassic epoch, is posterior to the first appearance of truly terrestrial *Amphibia*, and possibly of true reptiles, in the Carboniferous epoch (Middle Palæozoic) by a prodigious interval of time.

The water-population of vertebrated animals first appears in the Upper Silurian. Therefore, if we found ourselves on vertebrated animals and take "fowl" to mean birds only, or, at most, flying vertebrates, natural science says that the order of succession was water, land, and air population, and not—as Mr. Gladstone, founding himself on Genesis, says—water, air, land population. If a chronicler of Greece affirmed that the age of Alexander preceded that of Pericles and immediately succeeded that of the Trojan War, Mr. Gladstone would hardly say that this order is "understood to have been so affirmed by historical science that it may be taken as a demonstrated conclusion and established fact." Yet natural science "affirms" his "fourfold order" to exactly the same extent—neither more nor less.

Suppose, however, that "fowl" is to be taken to include flying insects. In that case, the first appearance of an air-population must be shifted back for long ages, recent discovery having shown that they occur in rocks of Silurian age. Hence, there might still have been hope for the fourfold order, were it not that the Fates unkindly determined that scorpions—"creeping things that creep on the earth" *par excellence*—turned up in Silurian strata, nearly at the same time. So that, if the word in the original Hebrew translated "fowl" should really, after all, mean "cockroach"—and I have great faith in the elasticity of that tongue in the hands of biblical exegetes—the order primarily suggested by the existing evidence—

2. Land and air population,
1. Water-population,

and Mr. Gladstone's order—

3. Land-population,
2. Air-population,
1. Water-population,

can by no means be made to coincide. As a matter of fact, then, the statement so confidently put forward turns out to be devoid of foundation and in direct contradiction of the evidence at present at our disposal.*

* It may be objected that I have not put the case fairly, inasmuch as the solitary insect's wing which was discovered twelve months ago in Silurian rocks, and which is, at present, the sole evidence of insects older than the Devonian epoch, came from strata of Middle Silurian age, and is therefore older than the scorpions which, within the last two years, have been found in Upper Silurian strata in Sweden, Britain, and the United States. But no one who comprehends the nature of the evidence afforded by fossil remains would venture to say that the non-discovery of scorpions in the Middle Silurian strata, up to this time, affords any more ground for supposing that they did not exist, than the non-discovery of flying insects in the Upper Silurian strata, up to this time, throws any doubt on

If, stepping beyond that which may be learned from the facts of the successive appearance of the forms of animal life upon the surface of the globe, in so far as they are yet made known to us by natural science, we apply our reasoning faculties to the task of finding out what those observed facts mean, the present conclusions of the interpreters of Nature appear to be no less directly in conflict with those of the latest interpreter of Genesis.

Mr. Gladstone appears to admit that there is some truth in the doctrine of evolution, and indeed places it under very high patronage:

> I contend that evolution in its highest form has not been a thing heretofore unknown to history, to philosophy, or to theology. I contend that it was before the mind of Saint Paul when he taught that in the fullness of time God sent forth his Son, and of Eusebius, when he wrote the "Preparation for the Gospel," and of Augustine when he composed the "City of God" (p. 706).

Has any one ever disputed the contention thus solemnly enunciated that the doctrine of evolution was not invented the day before yesterday? Has any one ever dreamed of claiming it as a modern innovation? Is there any one so ignorant of the history of philosophy as to be unaware that it is one of the forms in which speculation embodied itself long before the time either of the Bishop of Hippo or of the Apostle to the Gentiles? Is Mr. Gladstone, of all people in the world, disposed to ignore the founders of Greek philosophy, to say nothing of Indian sages, to whom evolution was a familiar notion ages before Paul of Tarsus was born? But it is ungrateful to cavil at even the most oblique admission of the possible value of one of those affirmations of natural science which really may be said to be "a demonstrated conclusion and established fact." I note it with pleasure, if only for the purpose of introducing the observation that, if there is any truth whatever in the doctrine of evolution as applied to animals, Mr. Gladstone's gloss on Genesis in the following passage is hardly happy:

> God created—
> (*a*) The water-population;
> (*b*) The air-population.
> And they receive his benediction (verses 20–23).
> 6. Pursuing this regular progression from the lower to the higher, from the simple to the complex, the text now gives us the work of the sixth "day," which supplies the land-population, air and water having been already supplied (pp. 695, 696).

The gloss to which I refer is the assumption that the "air-population" forms a term in the order of progression from lower to higher, from simple to complex—the place of which lies between the water-population below and the land-population above—and I speak of it

the certainty that they existed, which is derived from the occurrence of the wing in the Middle Silurian. In fact, I have stretched a point in admitting that these fossils afford a colorable pretext for the assumption that the land and air population were of contemporaneous origin.

as a "gloss," because the pentateuchal writer is nowise responsible for it.

But it is not true that the air-population, as a whole, is "lower" or less "complex" than the land-population. On the contrary, every beginner in the study of animal morphology is aware that the organization of a bat, of a bird, or of a pterodactyl, presupposes that of a terrestrial quadruped; and that it is intelligible only as an extreme modification of the organization of a terrestrial mammal or reptile. In the same way, winged insects (if they are to be counted among the "air-population") presuppose insects which were wingless, and therefore, as "creeping things," were part of the land-population. Thus theory is as much opposed as observation to the admission that natural science indorses the succession of animal life which Mr. Gladstone finds in Genesis. On the contrary, a good many representatives of natural science would be prepared to say, on theoretical grounds alone, that it is incredible that the "air-population" should have appeared before the "land-population"—and that, if this assertion is to be found in Genesis, it merely demonstrates the scientific worthlessness of the story of which it forms a part.

Indeed, we may go further. It is not even admissible to say that the water-population, as a whole, appeared before the air and the land populations. According to the Authorized Version, Genesis especially mentions among the animals created on the fifth day "great whales," in place of which the Revised Version reads "great sea monsters." Far be it from me to give an opinion which rendering is right, or whether either is right. All I desire to remark is, that if whales and porpoises, dugongs and manatees, are to be regarded as members of the water-population (and if they are not, what animals can claim the designation?), then that much of the water-population has as certainly originated later than the land-population as bats and birds have. For I am not aware that any competent judge would hesitate to admit that the organization of these animals shows the most obvious signs of their descent from terrestrial quadrupeds.

A similar criticism applies to Mr. Gladstone's assumption that, as the fourth act of that "orderly succession of times" enunciated in Genesis, "the land-population consummated in man."

If this means simply that man is the final term in the evolutional series of which he forms a part, I do not suppose that any objection will be raised to that statement on the part of students of natural science. But if the pentateuchal author goes further than this, and intends to say that which is ascribed to him by Mr. Gladstone, I think natural science will have to enter a *caveat*. It is not by any means certain that man—I mean the species *Homo sapiens* of zoölogical terminology—has "consummated" the land-population in the sense of appearing at a later period of time than any other. Let me make my meaning clear by an example. From a morphological point of view,

our beautiful and useful contemporary—I might almost call him colleague—the Horse (*Equus caballus*), is the last term of the evolutional series to which he belongs, just as *Homo sapiens* is the last term of the series of which he is a member. If I want to know whether the species *Equus caballus* made its appearance on the surface of the globe before or after *Homo sapiens*, deduction from known laws does not help me. There is no reason that I know of why one should have appeared sooner or later than the other. If I turn to observation, I find abundant remains of *Equus caballus* in Quaternary strata, perhaps a little earlier. The existence of *Homo sapiens* in the Quaternary epoch is also certain. Evidence has been adduced in favor of man's existence in the Pliocene or even in the Miocene epoch. It does not satisfy me; but I have no reason to doubt that the fact may be so, nevertheless. Indeed, I think it is quite possible that further research will show that *Homo sapiens* existed, not only before *Equus caballus*, but before many other of the existing forms of animal life; so that, if all the species of animals have been separately created, man, in this case, would by no means be the "consummation" of the land-population.

I am raising no objection to the position of the fourth term in Mr. Gladstone's "order"—on the facts, as they stand, it is quite open to any one to hold, as a pious opinion, that the fabrication of man was the acme and final achievement of the process of peopling the globe. But it must not be said that natural science counts this opinion among her "demonstrated conclusions and established facts," for there would be just as much, or as little, reason for ranging the contrary opinion among them.

It may seem superfluous to add to the evidence that Mr. Gladstone has been utterly misled in supposing that his interpretation of Genesis receives any support from natural science. But it is as well to do one's work thoroughly while one is about it; and I think it may be advisable to point out that the facts, as they are at present known, not only refute Mr. Gladstone's interpretation of Genesis in detail, but are opposed to the central idea on which it appears to be based.

There must be some position from which the reconcilers of science and Genesis will not retreat, some central idea the maintenance of which is vital and its refutation fatal. Even if they now allow that the words "the evening and the morning" have not the least reference to a natural day, but mean a period of any number of millions of years that may be necessary; even if they are driven to admit that the word "creation," which so many millions of pious Jews and Christians have held, and still hold, to mean a sudden act of the Deity, signifies a process of gradual evolution of one species from another, extending through immeasurable time; even if they are willing to grant that the asserted coincidence of the order of Nature with the "fourfold order" ascribed to Genesis is an obvious error instead of an established truth—they are surely prepared to make a last stand upon the conception

which underlies the whole, and which constitutes the essence of Mr. Gladstone's "fourfold division, set forth in an orderly succession of times." It is, that the animal species which compose the water-population, the air-population, and the land-population respectively, originated during three distinct and successive periods of time (and only during those periods of time).

This statement appears to me to be the interpretation of Genesis which Mr. Gladstone supports, reduced to its simplest expression. "Period of time" is substituted for "day"; "originated" is substituted for "created"; and any order required for that adopted by Mr. Gladstone. It is necessary to make this proviso, for if "day" may mean a few million years, and "creation" may mean evolution, then it is obvious that the order (1) water-population, (2) air-population, (3) land-population, may also mean (1) water-population, (2) land-population, (3) air-population; and it would be unkind to bind down the reconcilers to this detail when one has parted with so many others to oblige them.

But even this sublimated essence of the pentateuchal doctrine (if it be such) remains as discordant with natural science as ever.

It is not true that the species composing any one of the three populations originated during any one of three successive periods of time, and not at any other of these.

Undoubtedly, it is in the highest degree probable that animal life appeared first under aquatic conditions; that terrestrial forms appeared later, and flying animals only after land animals; but it is, at the same time, testified by all the evidence we possess, that the great majority, if not the whole, of the primordial species of each division have long since died out, and have been replaced by a vast succession of new forms. Hundreds of thousands of animal species, as distinct as those which now compose our water, land, and air populations, have come into existence and died out again, throughout the æons of geological time which separate us from the lower Palæozoic epoch, when, as I have pointed out, our present evidence of the existence of such distinct populations commences. If the species of animals have all been separately created, then it follows that hundreds of thousands of acts of creative energy have occurred at intervals throughout the whole time recorded by the fossiliferous rocks; and, during the greater part of that time, the "creation" of the members of the water, land, and air populations must have gone on contemporaneously.

If we represent the water, land, and air populations by *a*, *b*, and *c* respectively, and take vertical succession on the page to indicate order in time, then the following schemes will roughly shadow forth the contrast I have been endeavoring to explain:

Genesis (as interpreted by Mr. Gladstone).	Nature (as interpreted by natural science).
$b\ b\ b$	$c^1\ a^2\ b^2$
$c\ c\ c$	$c\ \ a^2\ b^1$
$a\ a\ a$	$b\ \ a^1\ b$
	$a\ \ a\ \ a$

So far as I can see, there is only one resource left for those modern representatives of Sisyphus, the reconcilers of Genesis with science; and it has the advantage of being founded on a perfectly legitimate appeal to our ignorance. It has been seen that, on any interpretation of the terms water-population and land-population, it must be admitted that invertebrate representatives of these populations existed during the lower Palæozoic epoch. No evolutionist can hesitate to admit that other land-animals (and possibly vertebrates among them) may have existed during that time, of the history of which we know so little; and, further, that scorpions are animals of such high organization that it is highly probable their existence indicates that of a long antecedent land-population of a similar character.

Then, since the land-population is said not to have been created until the sixth day, it necessarily follows that the evidence of the order in which animals appeared must be sought in the record of those older Palæozoic times in which only traces of the water-population have as yet been discovered.

Therefore, if any one chooses to say that the creative work took place in the Cambrian or Laurentian epoch in exactly that manner which Mr. Gladstone does and natural science does not affirm, natural science is not in a position to disprove the accuracy of the statement. Only one can not have one's cake and eat it too, and such safety from the contradiction of Science means the forfeiture of her support.

Whether the account of the work of the first, second, and third days in Genesis would be confirmed by the demonstration of the truth of the nebular hypothesis; whether it is corroborated by what is known of the nature and probable relative antiquity of the heavenly bodies; whether, if the Hebrew word translated "firmament" in the Authorized Version really means "expanse," the assertion that the waters are partly under this "expanse" and partly above it would be any more confirmed by the ascertained facts of physical geography and meteorology than it was before; whether the creation of the whole vegetable world, and especially of "grass, herb yielding seed after its kind, and tree bearing fruit," before any kind of animal is "affirmed" by the apparently plain teaching of botanical paleontology, that grasses and fruit-trees originated long subsequently to animals—all these are questions which, if I mistake not, would be answered decisively in the negative by those who are specially conversant with the sciences involved. And it must be recollected that the issue raised by Mr. Gladstone is not whether, by some effort of ingenuity, the pentateuchal story can be shown to be not disprovable by scientific knowledge, but whether it is supported thereby.

There is nothing, then, in the criticisms of Dr. Réville but what rather tends to confirm than to impair the old-fashioned belief that there is a revelation in the Book of Genesis (p. 694).

The form into which Mr. Gladstone has thought fit to throw this opinion leaves me in doubt as to its substance. I do not understand how a hostile criticism can, under any circumstances, tend to confirm that which it attacks. If, however, Mr. Gladstone merely means to express his personal impression, "as one wholly destitute of that kind of knowledge which carries authority," that he has destroyed the value of these criticisms, I have neither the wish nor the right to attempt to disturb his faith. On the other hand, I may be permitted to state my own conviction that, so far as natural science is involved, M. Réville's observations retain the exact value they possessed before Mr. Gladstone attacked them.

Trusting that I have now said enough to secure the author of a wise and moderate disquisition upon a topic which seems fated to stir unwisdom and fanaticism to their depths, a fuller measure of justice than has hitherto been accorded to him, I retire from my self-appointed championship, with the hope that I shall not hereafter be called upon by M. Réville to apologize for damage done to his strong case by imperfect or impulsive advocacy. But perhaps I may be permitted to add a word or two, on my own account, in reference to the great question of the relations between science and religion, since it is one about which I have thought a good deal ever since I have been able to think at all, and about which I have ventured to express my views publicly, more than once, in the course of the last thirty years.

The antagonism between science and religion, about which we hear so much, appears to me to be purely factitious—fabricated, on the one hand, by short-sighted religious people who confound a certain branch of science, theology, with religion; and, on the other, by equally short-sighted scientific people who forget that science takes for its province only that which is susceptible of clear intellectual comprehension, and that outside the boundaries of that province they must be content with imagination, with hope, and with ignorance.

It seems to me that the moral and intellectual life of the civilized nations of Europe is the product of that interaction, sometimes in the way of antagonism, sometimes in that of profitable interchange, of the Semitic and the Aryan races, which commenced with the dawn of history, when Greek and Phœnician came in contact, and has been continued by Carthaginian and Roman, by Jew and Gentile, down to the present day. Our art (except, perhaps, music) and our science are the contributions of the Aryan; but the essence of our religion is derived from the Semite. In the eighth century B. C., in the heart of a world of idolatrous polytheists, the Hebrew prophets put forth a conception of religion which appears to me to be as wonderful an inspiration of genius as the art of Pheidias or the science of Aristotle.

"And what doth the Lord require of thee, but to do justly, and to love mercy, and to walk humbly with thy God?"

If any so-called religion takes away from this great saying of Micah, I think it wantonly mutilates, while, if it adds thereto, I think it obscures, the perfect ideal of religion.

But what extent of knowledge, what acuteness of scientific criticism, can touch this, if any one possessed of knowledge or acuteness could be absurd enough to make the attempt? Will the progress of research prove that justice is worthless, and mercy hateful; will it ever soften the bitter contrast between our actions and our aspirations; or show us the bounds of the universe, and bid us say, Go to, now we comprehend the infinite?

A faculty of wrath lay in those ancient Israelites, and surely the prophet's staff would have made swift acquaintance with the head of the scholar who had asked Micah whether, peradventure, the Lord further required of him an implicit belief in the accuracy of the cosmogony of Genesis!

What we are usually pleased to call religion nowadays is, for the most part, Hellenized Judaism; and, not unfrequently, the Hellenic element carries with it a mighty remnant of old-world paganism and a great infusion of the worst and weakest products of Greek scientific speculation; while fragments of Persian and Babylonian, or rather Accadian, mythology burden the Judaic contribution to the common stock.

The antagonism of science is not to religion, but to the heathen survivals and the bad philosophy under which religion herself is often well-nigh crushed. And, for my part, I trust that this antagonism will never cease; but that, to the end of time, true Science will continue to fulfill one of her most beneficent functions, that of relieving men from the burden of false science which is imposed upon them in the name of religion.

This is the work that M. Réville and men such as he are doing for us; this is the work which his opponents are endeavoring, consciously or unconsciously, to hinder.—*Nineteenth Century.*

RECENT EXPERIMENTS IN STATE TAXATION.

By HENRY JAMES TEN EYCK.

TO growl is the privilege of the tax-payer. To secure the entire amount of the necessary revenue with the smallest growl is the aim of the legislator. Probably there is no more unpopular official than the tax-gatherer. Among persons of property the idea seems to prevail that taxation is a kind of robbery which is to be evaded if possible. It is true that the public treasury has often been filled simply that thieves might plunder it, or that worthless citizens might be supported

at public expense, as a reward for their political work. This is the case particularly in the administration of municipal affairs. The national and State governments have been conducted, in spite of the observance of the odious spoils system, with an efficiency and economy unequaled by but few great business houses. Even better service would undoubtedly be obtained if the public had a fuller appreciation of the truth of the old paradox that the dearest labor is the cheapest. More liberal salaries for positions of trust and executive control would tend to elevate decidedly the standard and ability of the men in the public service. But, unfortunately, propositions of this character do not meet with general approval. The vulnerable spot of the American is his pocket-book. When an official lays his hands on that, the victim resents the attack with indignation, and submits, after loud protestations and threats, to the demand for his money, only out of respect for the superior power of the law. The dominant party, in attempting to carry on the government satisfactorily, and, at the same time, not arouse the voter who pays the taxes, has a difficult problem to solve. In the United States, where the voter is the ruler, political managers find it essential to continued success to make the drafts on the ruler's pocket-book as light as possible. All parties would be happy if the public treasury could be filled by the touch of a magician's wand, so that taxes might be abolished. But, as they are a necessary evil, a scheme of taxation without lamentation is what is wanted. In the law laid down by Professor William G. Sumner, that taxation tends to diffuse itself, but on the line of least resistance, is found a hint for the basis of this scheme. Turgot, the great French financier, expressed the politician's idea very tersely when he said that the science of taxation is to pluck the goose without making it cry. In hunting for the line of least resistance, and the most scientific methods of plucking, several interesting experiments have been made of late in different States, where new sources of revenue have been sought from special taxes on corporations, railroads, telegraph, telephone, and insurance companies, collateral inheritances, and other classes of property which can be plucked without producing a cry liable to strike a chord of sympathy in the popular heart. In most instances these experiments have surpassed in their results the expectations of the proposers. Large revenue has been obtained without provoking even a murmur of disapproval from the voting classes. In Vermont, for example, no direct tax was levied in 1883 and 1884, the receipts under the corporation tax law paying the expenses of the State government. The Comptroller of New York received $9,569,161.35 in 1884, of which $1,603,612.75 were paid by corporations. Last year,* although the Wisconsin Legislature authorized a levy of $240,000, the State Treasurer was not obliged to collect any direct tax, as the license-tax from railroads, insurance, telegraph, and telephone companies was sufficient to meet the current expenses. The Treasurer

* 1884. The article was written June, 1885.

of Minnesota states that "the revenue from the corporation tax is steadily increasing, and if it should continue to increase, and the probabilities are that it will, as it has done for the last four years, it bids fair to pay all the expenses of the State government." In New Jersey there is no regular tax, except for schools, as the new railroad and canal tax law and the tax on miscellaneous corporations maintain the government.

These are striking illustrations of the workings of a new system of imposing special taxes on special classes of property, which was only first tried about ten years ago. The idea of treating railroads and corporations generally in a different manner in the tax levies from other kinds of property was a development, perhaps, of the granger and anti-monopoly movements. It is founded on the theory that parties enjoying special privileges from the State should share with the State, to some extent, the profits of their enterprises. If the Government gives certain individuals peculiar advantages and protection in the inauguration and prosecution of their schemes and business, it is held that they should make a return for the favors granted, in proportion to the success of their undertaking. In every State where the plan has been tried it has worked admirably. After a stout resistance on the part of the corporations, resulting in a judicial interpretation of all the provisions of the statute, the execution of the new law goes on smoothly in each State. The largest corporations naturally fight every encroachment on their sources of income, but when the law is once in full operation they submit gracefully. The various Legislatures adopting the system have endeavored not to make the tax too heavy. If the rate is moderate it inflicts no serious burden on the corporations, and yet brings a handsome sum into the public treasury. The benefits of this new plan have, so far, been appreciated only in the New England, Middle, and Northwestern States. Twelve States now impose special taxes on railroads and other corporations. In eight more, including three Southern States, insurance companies are subject to a special rate. The ordinary method of levying a direct tax on real and personal property still furnishes, in the large majority of States, almost the entire revenue. The old poll-tax remains a favorite form of taxation in parts of New England and the South, twelve States raising most of their school funds in that way. An examination of the tax laws of each of the thirty-eight Commonwealths indicates, however, a steady development of the idea of "taxation without lamentation." The attack is not confined to corporations. There is a reaching out in every direction for special subjects for taxation. If one State finds an object that can pay special rates without suffering materially, and without raising a popular outcry, other States follow in the line of the discovery. On the other hand, a number of experiments have been abandoned, after a year or two of trial, because the law was unconstitutional or unpopular. All the New England States have a tax on deposits in

savings-banks. Maryland, Virginia, and Pennsylvania tax collateral inheritances. In New Hampshire the courts recently declared a law of this kind unconstitutional. Nine States derive part of their revenue from a tax on the liquor-traffic. Eight secure a considerable amount from licenses granted to trades and occupations by the State, instead of by the local authorities, as is the custom in most sections. A few of the oddities of taxation by States may be referred to here. Maryland last year obtained $110,050 from a tax on the commissions of executors and administrators of estates, one tenth part of the sum allowed them by the Orphans' Court being demanded by the State. North Carolina derived $63,000, in 1884, from a license of $100 on drummers. The declaration of the Ohio Supreme Court, last autumn, that the Scott liquor law was unconstitutional, has deprived the State of an annual revenue of over $50,000, and the cities within its borders of half a million. Pennsylvania and Virginia have income-taxes. Georgia gets $300,000 per annum as the rental of the Atlanta and West Point Railroad, and Illinois has seven percentum of the gross earnings of the Illinois Central Railroad, between $350,000 and $400,000 a year, as a charter tax. In South Carolina seventeen companies paid a royalty, for the use of the phosphate-beds, of $154,318, which is about one quarter of the amount raised for State purposes. The occupation-tax in Texas covers a very extensive list of trades and occupations. The total receipts of the treasury in 1884 were $1,539,918, and of this sum the occupation-taxes furnished $774,756. In Massachusetts there is a law for the taxation of corporations. The levy is made by the State; but the amount paid in is redistributed by the State to the cities and towns where the stockholders reside, and only so much thereof as is from non-residents remains in the State Treasury. Pennsylvania, by some strange process of reasoning, thinks that a man who owns a watch should pay a tax for the privilege. As only 45,596 watches are reported by a population of 4,500,000, the inference is, that the Quakers either conceal their time-pieces in an inner pocket, or regulate their lives by the town-clock or the sun.

A glance at the laws of a few States which have secured the most notable results in the direction of special taxation will show the scope and bearing of the movement. Pennsylvania may, perhaps, be called the pioneer. It has tried more experiments and probably reaches more special classes than any other State. The tax on the capital stock of all corporations, which yielded to the State $1,535,727.56 in 1884, is one half mill for each one per centum of dividend declared, provided the annual dividend amounts to six per centum or more. If the dividends are less than six per centum, or if there are no dividends, the tax is three mills upon each dollar of the appraised valuation, or market value, of the stock. A further tax of eight tenths of one per centum is imposed on the gross earnings of transportation and telegraph companies. This brought in last year $787,929.20. Insurance

companies are assessed eight tenths of one per centum on gross premiums, and bank-stocks, mortgages, and loans of different kinds pay four per centum on every dollar of the value thereof. These special classes paid $954,843.59 in 1884. Collateral inheritances of over $200 are taxed three mills on every dollar. From this source $461,465.48 were derived. Tavern-licenses amounted to $426,429.19, and retailers' licenses to $301,393.42. Nothing illustrates better how effectively this system of special taxation can be applied than the fact that while the total receipts of the Pennsylvania State Treasury in 1884 were $6,226,959.38, only $502,025.43 were raised by a direct general tax. New York State, which is first in wealth and the amount of revenue collected, has not pushed the system to such an extent, although it is rapidly following in the course of its neighbor. The tax on the capital stock of corporations is only one half of that levied in Pennsylvania, namely, one quarter of a mill for each one per centum of dividends if the dividends equal or exceed six per centum, and one and one half mill upon each dollar of a valuation of the capital stock when they are under six per centum or *nil*. The tax on the gross earnings of transportation, navigation, telegraph, and telephone companies is one half per centum. This yielded in 1884 $1,603,612.75, insurance companies paying on their capital and premiums $241,676.15 of the amount. In Wisconsin, where special taxes have also worked well, the plan is somewhat different. The license-tax, as it is called there, applies to railroads, insurance, telegraph, and telephone companies. Railroads are taxed from five dollars per mile of operated road to four per centum of gross earnings, as follows: If the road earns less than $1,500 per mile, it is taxed five dollars per mile; on those earning more than $1,500 and less than $3,000 per mile, the tax is five dollars per mile, and two per centum on the excess over $1,500 per mile; on those earning $3,000 or more per mile, the tax is four per centum on gross earnings. Telegraph companies pay one dollar per mile for the first wire, fifty cents per mile for the second, twenty-five cents per mile for the third, and twenty cents per mile for the fourth and all additional. Telephone companies pay one per centum on gross receipts, and insurance companies two per centum on gross earnings. This tax or license is in lieu of all other taxes, and amounted in 1884 to: Railroads, $754,269.44; telegraph, $4,568.85; telephone, $1,169.26; insurance, $64,904.75; or a total of $824,912.30. Vermont, which pays nearly its entire expenses out of the special taxes, has a law somewhat similar to that of Wisconsin. It levies two per centum on railroads on the first $2,000 of earnings per mile. The rate increases one per centum for each additional $1,000 per mile up to $5,000, and on all earnings over $5,000 per mile it is five per centum. Insurance companies pay two per centum on gross premiums, and life-insurance companies in addition one per centum on all surplus over the necessary reserve computed at four per centum on existing policies. Savings-

banks pay one half per centum on deposits; express, telegraph, and telephone companies, three per centum on gross earnings, and steamboats two per centum. These quotations are sufficient to show the methods of corporation taxation.

The expediency and justice of a tax on collateral inheritances is not so readily admitted. Although it has been enforced as a war-tax, it is somewhat of an innovation on the principles of taxation observed in this country. There is a slight flavor of communism in the idea, yet the proposition is not altogether objectionable, and may be sustained by good arguments. A law of a similar character has been in operation in England many years. It is held to be in the nature of a franchise or license tax, upon the right derived from the state of transmitting property, and is inflicted only when property is bequeathed out of the immediate family. If there are no constitutional objections, the recipients of the bequests certainly have no cause for complaint, if the Government compels them to pay a small share of their gift for its support. A Pennsylvania man, for instance, who receives a windfall of $100,000 from a distant relative or an intimate friend, will obtain no sympathy if he growls because he is obliged to turn over $3,000 of it into the public treasury. He is better able to do so than any other man who has acquired his property by hard toil and individual exertion and enterprise. In Maryland the rate is two and one half per centum on every $100 of collateral inheritances over $500, and the tax yielded, last year, $86,218.46. The New York Legislature last winter passed a bill imposing a tax of five per centum on similar bequests. Although it aroused some opposition, Governor Hill signed the measure, with a recommendation that it be amended next winter so as to place the limit at $5,000 instead of $500, it being argued that in its present form it might place heavy burdens on poor persons who might receive small bequests of $1,000 or $2,000. It is estimated that the new law will yield annually in New York between $750,000 and $1,000,000. Evidences of the spread of the idea of "taxation without lamentation" are found in the recent proceedings of the Legislatures of other States. In Pennsylvania a bill was introduced, in April last, imposing a tax of five mills on the interest of deposits in savings-banks having no capital stock. There are obvious reasons for not taxing deposits in savings-banks, and it is to be hoped that this sort of special taxation will not be more extensively adopted. Notwithstanding the disastrous results, politically, in other States, of a heavy tax on the liquor-traffic, Illinois has just placed on its statute-books a law imposing a tax of $500 per annum on the sale of liquors, and $150 per annum on the sale of beer. In California, at the last session, a bill was passed to submit to the people an amendment to the Constitution providing that railroads shall pay an annual tax of two and a half per centum on gross earnings, and also that income-taxes may be assessed and collected from persons and corporations. The existing laws, and

these recent efforts to secure additional statutes for raising the State revenues by means of special taxation, mark the development of new methods of taxation based principally on the growth of corporate wealth and the prosperity of certain privileged and, in some cases, like the liquor-traffic, objectionable classes of industry and business. The proportion of the States in which they are on trial is as yet small. The number, however, is steadily increasing. As the advantages of the new plan are brought more clearly before the notice of legislators, we may expect a revolution in State taxation. So great has been the progress in the past ten years that it would not be astonishing to see at the end of the next decade fully one half of the States levying merely a nominal direct tax, or none at all. Special privileged classes will probably bear the burden of State taxation in the future. The tariff will furnish the national revenue, and the main tax on real and personal property will be for the necessities of county and municipal government. The only danger lies in a tendency to overdo the matter. The special taxes must not be oppressive. The rights of the special classes, as well as of the other tax-payers, must be protected. If co-operation between the States could be assured, so that uniform and equitable rates might be established, great benefit would be derived by all property-owners.

BISHOP'S RING AROUND THE SUN.

By WILLIAM M. DAVIS.

IF there is nothing new under the sun, there is at least something new around it. For the last two years close observers of the sky have noticed that the noonday sun has been surrounded by a corona of dusky, coppery, or reddish light, as it has been variously described, the circle of most distinct color having a radius of about fifteen degrees, and inclosing a brilliant, silvery or bluish glow close around the solar disk. A similar appearance of much less intensity has been occasionally noticed around the full moon on very clear winter nights.

The most experienced observers of sky-colors are agreed that this corona was not visible before the latter months of 1883. Von Bezold, of Munich, who was considered the most competent meteorologist to prepare a schedule for observations on the colors of the sky for the recent German Arctic Expedition, says that, in spite of the close attention he had previously given to the appearance of the usual whitish glow around the sun, he had never till recently seen the dusky ring. Thollon, of Nice, who had made a special study of the sky around the sun for a series of years, declares confidently that a change occurred in November, 1883. Backhouse, of Sunderland, who has a careful

record of parhelia for twenty-five years, confirms this opinion. We may, therefore, safely accept the conclusion that the change of color from the blue of the open sky to the intense glare of whitish light close around the sun, was until lately effected without the appearance of any reddish tinge in the transitional area.

The new corona, to which the name of "Bishop's ring" has been given after its first observer, has never been a very conspicuous affair, and therefore has not attracted the popular attention that it deserves; but it could easily be seen every clear day last winter, and has repeatedly been noticed since then in the latter months of 1885. The hazy days of summer are not favorable to its visibility. It is best seen from elevated stations, which gain their sky-colors chiefly from the finer particles floating at great altitudes, as they are above the lower strata of the atmosphere where the relatively coarse, haze-making dust is suspended. Forel, of Morges, one of the most acute observers of terrestrial physics in Switzerland, reports the distinct visibility of the ring from mountain-tops, while it is not to be seen from the valleys, where the whitish, hazy light overpowers its delicate colors. He adds that many of his countrymen in the higher Alps had been struck with the appearance of the new color in the sky before they had heard mention of it. For the same reason Tissandier found the distinctness of the corona greatly increased when viewed from a balloon high above the dusty air of Paris. At low-level stations it is best seen during the persistence of that type of weather known as "anti-cyclonic" among modern meteorologists. Such weather is characterized by high barometric pressure, and consequently has descending currents of pure, clean upper air. The sky is then brilliantly clear and free from haze, and at such times last winter the ring was of remarkable distinctness. Thin cirrus clouds generally hide it; but the presence of scattered, sharp-edged cumulus clouds adds to its visibility in the clear spaces between them. Let one of them stand before the sun, so that its heavy shadow darkens the lower air, whose reflecting particles ordinarily add much white light to the blue of the sky; then, looking between the clouds in the neighborhood of the sun, a broad arc of the ring appears with its colors blending in what may be fairly called the most delicate intensity. Just before a moderate thunder-storm early last June, the ring was thus presented with most beautiful effect. It was seen in Cambridge with extraordinary distinctness on the afternoon of November 2, 1885, when the lower clouds of a heavy rain-storm rapidly broke away in the west, about two o'clock, leaving the sun well hidden behind a sheet of upper cloud and a space of open sky below it. The lower air was thus well shaded from direct sunlight, and the strength of the colors was most remarkable. There was first the margin of the glowing central area at the edge of the cloud, soon turning pale brassy yellow, and then strong reddish gold at about fifteen to twenty degrees from the sun; farther out yet was the delicate

rosy or purplish-pink, and at last the pure blue of the sky. The colors were wonderfully vivid for the time of day, although, of course, not so brilliant as those of a well-developed sunset; but it unfortunately seems to have very generally passed unnoticed. Inquiry among my neighbors failed to discover any one who had seen it.

Numerous observations in many parts of Europe and this country leave little room for question that the corona is produced in the upper atmosphere, and that it was continuously present above the cloudy or dusty lower air over a large part if not over the whole of the earth throughout 1884 and 1885.

The explanation of the optical process by which such a corona may be produced offers no particular difficulty. It is a relatively simple effect of diffraction, an effect of the same nature as that seen in the colored rings surrounding a light looked at through a glass that is faintly frosted over, as may be noticed almost any cold winter evening when looking out of a window. A brief statement of the process may be made, following the explanation given by Kiessling, to whom the author is much indebted in the preparation of this article.

Let us first consider the action of a beam of parallel rays of monochromatic light—that is, of strictly one-colored light, whose waves all agree in their period of vibration—as it passes an excessively fine thread stretched at right angles to its path, and falls on a screen beyond. The waves will be turned aside from and bent around both sides of the thread, as if diverging there from new centers of radiation. This is diffraction. A gross figure of the process is here given (Fig. 1) on a plane at right angles to the thread, T H. The point A

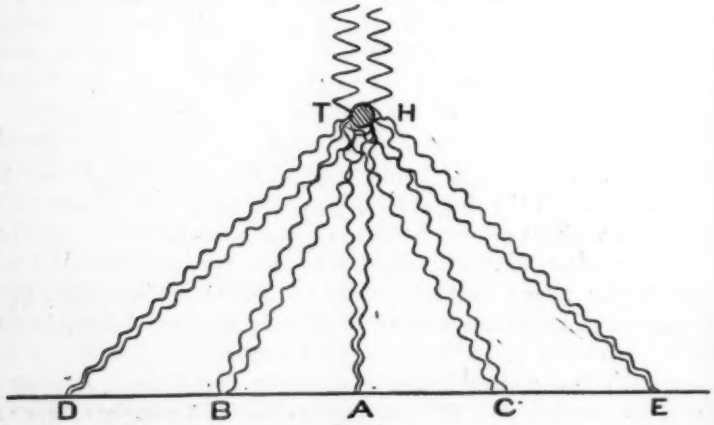


FIG. 1.

on the screen will be illuminated, although it is behind the thread, for the waves that reach A from either side of the thread agree in phase. Take a point, B or C, such that the distance B H exceeds B T by half a wave-length. Then the diffracted waves which agreed in phase at

the thread will be just opposed at B, the crest of one will fall with the trough of the other; they are thus extinguished by interference, and darkness will result. Take another point, D, on the screen, such that D H differs from D T by a whole wave-length. Now the diffracted waves will agree in phase at D, and this point will be illuminated, like A. The screen will therefore be marked by a bright band behind the thread, and by dark and bright bands, blending together and parallel to it on either side. Their breadth will vary directly as the wave-length, and inversely as the diameter of the thread. The redder the ray and the finer the thread, the broader the bands.

Next consider the case of a single small particle of diameter greater than the wave-length in the path of the monochromatic beam. The same figure now may represent a plane parallel to the rays, passing through the particle in any direction. The parallel bands become concentric rings with a bright central spot behind the particle. The diameter of the rings varies, as above stated for the bands. The bluer the light and the larger the particle, the narrower the rings.

The next step makes an approach to the actual case by supposing a great number of one-sized particles floating in the space traversed by the waves, and considers their effect as perceived by an observer at A (Fig. 2). The unaltered light is seen in the direction of the rays

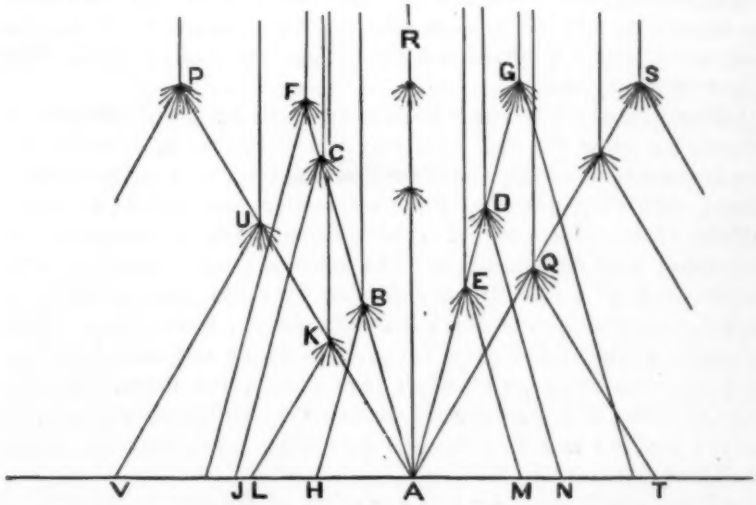


FIG. 2.

A R. Interference of the waves diffracted from B causes a dark circle on the surface V T, of diameter A H; from C, a circle A J; from D, a circle A N. Hence all the particles situated on the surface of a cone whose axis is A R, and apical angle is F A G, give no light to A, and the luminous center R seems to be surrounded by a dark ring at an angular distance R A F. This may be called a subjective ring in

distinction from the objective rings, A H, A J, A N. In the same way, the particles situated on the cone P A S will contribute to the formation of a bright subjective ring of radial angle R A P. The center R will appear to be surrounded by dark and bright rings.

Now we must introduce the supposition of many-colored or polychromatic light—the white light of many wave-lengths that comes from the sun. Such light, passing a fine thread, forms a series of prismatic bands on a screen; passing a single particle, it forms a series of concentric prismatic rings with the blue inside; for the first blue ring will fall a little inside of the first yellow, and the first yellow inside of the first red—and so on with the others, until at a distance from the center the outer rings overlap irregularly. The subjective rings seen when white light passes through a transparent medium containing many one-sized particles will, for the same reason, appear many-colored, with the blue inside and the red outside; the central area will be white, with a reddish margin.

Finally, the actual case is reached when the suspended particles are of different sizes. The colors of the central area now overlap so irregularly that they unite to form a whitish or silvery disk; but the outer red margin of the central area formed by the smallest particles is still uncounterbalanced. The silvery disk will be reddish about the circumference; and the colors thus deduced by theory are so closely like those observed in Bishop's ring around the sun that it may be safely considered a diffraction corona. The outer rings are too faint to be seen in daytime.

Colored coronal rings may be seen around a light when looking at it through a glass strewed lightly over with spores of lycopodium; they are so nearly of the same size that a number of concentric rings appear. Kiessling describes some interesting experiments with thin artificial clouds of condensed vapors, through which the sun is seen surrounded with coronal rings. The moon is often surrounded with similar rings of small diameter, formed by diffraction, probably on small floating particles of ice, even when the sky seems clear. These are easily distinguished from halos. The latter are of definite and much larger diameter, and, when seen around the moon, are generally whitish; if formed around the sun, they are visibly colored with the red *inside;* and they are due to refraction and reflection on minute ice-crystals.

All this is safe enough; it is the origin of the diffracting particles and the long endurance of their effect that give trouble. Indeed, the experimental and mathematical knowledge of optics, based on the undulatory theory of light, has advanced so far that the physicist is now better able to suggest processes by which effects may be produced than the meteorologist is able to apply them. The physicist can safely say that a sufficient supply of extremely fine liquid or solid dust scattered through the atmosphere would produce just such a solar corona

as Bishop's ring. It is for the meteorologist to inquire whether a supply of dust sufficient in quantity and quality, appearing at the right time and enduring long enough, can be accounted for.

Kiessling, of Hamburg, already referred to, has done the best work on the corona as well as on the great sunsets with which it is evidently connected. His pamphlet, entitled "Die Dämmerungserscheinungen im Jahre 1883, und ihre physikalische Erklärung" (Hamburg, 1885), gives the most satisfactory account and explanation of the twilights that I have seen; and its value is largely increased by the experimental illustrations that the author has devised in imitation of the strange natural phenomena that he accounts for so well. A later paper, "Ueber die geographische Verbreitung des Bishop'schen Sonnenringes," in the May number of the little meteorological journal, "Das Wetter," and a short paper by Forel on "Le Cercle de Bishop," in the Geneva "Archives des Sciences" for June, are the most recent articles of consequence on the corona, and give important evidence as to the origin of its diffraction particles by showing its relation to the famous sunsets. The new corona was first noticed in Honolulu on the 5th of September, 1883, by the Rev. Sereno F. Bishop, who called attention to it by descriptions published at the time, and in letters to "Nature." Although seen so early in September in the Sandwich Islands, it was not recognized in this country till November 24th, when Professor Le Conte saw it at Berkeley, California; nor in Europe till the days directly following; but ever since then it has been continuously visible till now, in proper conditions of weather as already described. After rarely being seen in the summer, it has reappeared in the clearer days of the winter. Being always relatively inconspicuous, the date of its first visibility can not generally be determined with accuracy—alas for the neglect of so rare an opportunity of valuable observation!—but the agreement of the growth of the area in which it was noted and the spread of the great sunsets is placed beyond a doubt; and with them its origin must be referred to the explosive eruption of Krakatoa. Kiessling considers this relation of cause and effects to be firmly established, and even quotes approvingly the name given by Arcimis in Madrid, "corona solar krakatoense," although the name of "Bishop's ring" is undoubtedly the one that will come into general use.

The evident difficulties in the way of accepting the volcanic origin of the diffracting particles are the great quantity of material that would seem to be needed, the excessive fineness of its texture, and its long suspension in the thin upper air; but I believe that these difficulties are by no means fatal to the volcanic theory. The quantity needed is not absolutely so great, after all. Tyndall suggested that the minute, almost molecular particles, to which the blue color of the sky is usually referred, could all be contained in a snuff-box; and, while this need not be taken as in any way an accurate estimate of the

mass of matter involved, it may nevertheless serve to measure the very low order of its quantity. Many snuff-boxfuls were thrown out of Krakatoa. Moreover, the dust-particles may be very sparsely scattered; the miles of air through which they are spread compensating for the wide space between them. The fineness of the solid dust is a legitimate result of what is now known of the constitution of lavas. Microscopic examination of igneous rocks has shown lithologists how well a volcanic explosion can produce diffracting dust; high magnifying power, applied to rocks that are presumably old buried lavas which failed to reach the surface, reveals the presence of the minutest cavities containing liquids or gases or both, so small and so closely packed that myriads would be contained in a cubic inch: under the decreasing pressures found as lavas rise through a vent to escape at the surface outlet, the occluded gases and vapors would escape, and in so doing would shatter the lavas to the finest imaginable dust. It is probably by this intimate process, as well as by ordinary forms of mechanical violence, that Krakatoa was, figuratively, blown to atoms. The greater and coarser part of the dust darkened the sky for a day or two and soon fell on the surrounding lands and seas; a finer remnant was carried high into the air by the outrushing gases, and then spread far and wide over the earth to produce the marvelous sunsets; does the finest residue still hang aloft and give us Bishop's ring? How can it be suspended so long?

Kiessling's experiments have led him to believe that the coronal diffraction does not take place immediately around the volcanic dust-particles, but rather around the minute globules of water or ice condensed on these particles as nuclei. Recent researches have shown that water-vapor may remain in the gaseous state below the temperature proper to its condensation, provided there is no solid or liquid matter present on which the condensation can begin; the change from the gaseous to the liquid state seems to desire the presence of some point of beginning, such as is furnished by ordinary dust, or by the far finer, ultra-microscopical particles always present in the air. It is in part for this reason that great cities in damp countries must be hopelessly foggy; however perfect the combustion in their numerous furnaces, unburned ash in very fine division must fly up the chimneys as long as wood and coal are used, and the finer the ash the better for the fog, when the coolness for condensation arrives. Now, in connection with this, there is a very peculiar point to be considered, concerning the distribution of water-vapor in the atmosphere. Water-vapor is a light, elastic, condensible gas, and its elastic lightness is always tending to throw it to an altitude where the cold of its expansion would require a part of it to condense into the liquid or solid state. It can, as yet, hardly be said that some minute point of beginning is absolutely necessary for all such condensation, but it may be safely asserted that the presence of dust aids and increases the rapidity of the process;

and it is this office that the finest and highest of the Krakatoa dust is thought to have performed. And here a peculiar cycle of operations, first suggested by Wollaston years ago, and generally neglected since then, may be reconsidered. So long as the water-substance is in the vaporous condition, it acts as a gas, and tends to expand upward; part of it would thereby be condensed, generally in the solid state, and on losing the gaseous condition the frozen particles would at once tend to fall toward the earth, impeded only by the presence of the thin air; but, after a certain length of falling, they would reach air warm and dry enough to allow them to re-evaporate, whereupon their vapor would again expand upward, and the cycle of operations begins anew. Wollaston suggested that the gases of the air might be thus affected by the extreme cold of upper space, and that a limit of the atmosphere might so be determined. There is, however, no experimental evidence yet adduced to prove that oxygen and nitrogen would behave in such a way, and the limitation of the atmosphere must be due to other causes; but the upward extension of water-vapor might be thus controlled. May we not, therefore, imagine that the vapor of the upper atmosphere, re-enforced liberally by steam from Krakatoa and other volcanoes in eruption at the same time, found its opportunity for condensation much improved for several months by the lava-dust from the same sources; and thus explain the brilliant sunsets and the strength of color in Bishop's ring during the winter of 1883–'84? But gradually the dust settles down, very slowly on account of its large ratio of surface to weight; and the vapor also decreases by slow downward diffusion; then the brilliancy of the display is lost, and the moderate residual of vapor, condensing as well as it can alone, produces only a fainter-colored ring and sunset glows that are visible only under especially favorable circumstances.

Be all this as it may, it is well to bear in mind that some such explanation must be found and accepted, for the facts of diffracting particles and their relation to Krakatoa are too well proved to be doubted, unless evidence not yet forthcoming shall appear in great strength.

The ring is doomed to disappear, and hence deserves a close watching. For, as Forel has pointed out, the outburst of Krakatoa must have had its rivals in ancient if not in modern times, and rings like Bishop's must in all probability have resulted from former dusty explosions. But these had all faded long before Bishop's ring appeared, and we must, therefore, conclude that it will fade away also. It should be carefully watched, especially from high-level stations, and those who make a persevering record of it should not fail to inform Professor Kiessling, of Hamburg, about what they see.

CAMBRIDGE, MASSACHUSETTS, *December, 1885.*

THE INFLUENCE OF INVENTIONS UPON CIVILIZATION.

By CHAUNCEY SMITH.

IN Westminster Abbey, that place where England honors her great men with burial, and records their names and achievements, there stands a monument bearing this inscription from the pen of Lord Brougham, who esteemed it one of the greatest honors of his life that he was called upon to record the nation's appreciation of the man in whose honor the monument was erected:

"Not to perpetuate a name
Which must endure while the peaceful arts flourish,
But to show
That mankind have learned to honor those
Who best deserve their gratitude,
The King,
His Ministers, and many of the Nobles
And Commoners of the Realm,
Raised this monument to
James Watt,
Who, directing the force of an original Genius
Early exercised in Philosophic research,
To the improvement of
The steam-engine,
Enlarged the Resources of his Country,
Increased the Power of Man,
And rose to an eminent place
Among the most illustrious followers of Science
And the real Benefactors of the World."

The world has always paid homage to its distinguished warriors, statesmen, orators, poets, philanthropists, artists, historians, travelers, and to all who have left the impress of their works upon the history of mankind.

It is not until recently, however, that inventors have received a large share of these honors. As a class, they hardly had an existence till within a hundred years. Within that time they have risen to the highest place among those who, in the language of the eulogy I have just quoted, best deserve the gratitude of mankind, and by their works they have made greater changes in the face of society, and in the relations of civilized man to the physical world, than all the warriors and statesmen who have flourished since the commencement of the Christian era.

I am not unmindful, in making this statement, of the great changes that followed the introduction of the Christian religion, or the advent

of Mohammed and the rise of his religion, of the consequences which followed the establishment of great empires like that of Charlemagne, or of the results of geographical discovery, as in the discovery of America or of the passage to India.

I am well aware of the difficulty of comparing the magnitude or importance of such things, for instance, as the art of printing, the steam-engine, or the railway or telegraph, with a new form of religion, or the establishment or overthrow of an empire, or the introduction of new forms of government. One man may attach much higher importance to some of these things than another would do, and a very much higher importance to them at one period of his life than at another.

It may seem absurd to some persons to make any comparison, for instance, between the benefits flowing from the introduction of Sabbath-schools and those which have followed the invention of friction-matches; between the results due to the invention of spectacles and the consequences which followed the Reformation. And yet it is easy to see that each of these things must have had an important influence upon the physical, social, and moral condition of men, upon their habits of thought and of living, and upon their comfort and happiness. There is, therefore, some just relation between the value of these things to men, and it will not be unprofitable to spend a little time in considering how much we owe to inventors for what we have and what we are.

It is my purpose this evening to briefly bring into view, if I can, the service which inventors have rendered the world, and the part which inventions play in the moral and social condition of man. I shall point out in some cases the extreme simplicity of the inventions, in others the wonderful results which have flowed from them.

I shall refer not merely to what are called great inventions, but to some which seem to be very small. I shall very likely speak of nothing with which you are not all more or less familiar, but I may possibly suggest reflections which are interesting but which seldom come to our minds, for the very reason that we are so familiar with the things to which they relate; and I think that I may be able to show that there are no other men to whom the world is so much indebted as to its inventors, no others who so well merit its honors and deserve its gratitude.

We do not often stop to think how little man has or enjoys that is not the fruit of invention. Things which man has long had we have ceased to think of as inventions, and we are apt to apply that term only to modern things—to things the origin of which we know. Yet it will be hard for any of us to name anything which we use or enjoy which is not an invention, or the subject of an invention, in its adaptation to our use.

The air we breathe and the water we drink are provided by Nature. But we drink but very little water except from a cup or vessel of some kind, which is a human invention. Even if we drink from

the shell of a gourd, we are using a thing which, in the shape we use it, is a human contrivance, and the contrivances which man has devised for obtaining water and distributing it have been among the most wonderful and ingenious of any which have occupied the human mind. Bountifully as Nature has provided water and placed it within the reach of man, yet we do in fact get or use but little of it except by the aid of inventions.

The air surrounds us at all times and we can not help using it if we would; but, if we want it either hotter or colder than we find it, we must resort to some invention to gratify our want. If we want it to blow upon us when it is still, we must set it in motion by some contrivance, and fans among other things have been invented for that purpose. A large amount of human ingenuity has been expended upon devices for moving air when we want it moved, upon fans, blowers, and ventilators.

How small a part of our food do we take as animals do, in the form provided by Nature, and how very large a share in some form contrived by man! We drink infusions of tea or coffee without thinking that the compounds are human inventions. How large a place the milk of the cow has in the food of man, but how little of it could he have but for a multitude of contrivances! We think of butter as we do of milk, that it is a production of Nature; and so it is, but its separation from milk is an invention which has been followed by a host of inventions to effect the separation easier or better.

Sugar is a production of Nature, but little known a few hundred years ago. Separated from the plants in which it is formed, it is an invention of man. The savage who first crushed some kernels of wheat between two stones, and separated the mealy interior from the outer skin, invented flour, and the human mind has not yet ceased to be exercised on the subject of its improvement.

Probably the earliest inventions of man had reference to the procuring and preparing of food, and the ingenuity of man is exercised even now upon it more eagerly than ever before, and the power of man to produce food has been increased during the last fifty years more than it had been for a thousand years before.

Fifty years ago, a large part of the wheat and other grain raised in this country was cut, a handful at a time, with a sickle, and a man could not, as a rule, reap more than a quarter of an acre a day. An instrument called a cradle was beginning to come into use, and with that a man could reap about two acres.

Within fifty years inventors have given the world the reaping-machine, with which a man and two horses will cut from fifteen to twenty acres a day.

Fifty years ago the grain was almost wholly thrashed from the straw by pounding it upon a floor with a flail. If I remember cor-

rectly, a man sometimes received one bushel in ten for thrashing, and from ten to twenty bushels must have been a day's work.

Now a machine will thrash out hundreds of bushels in a day, at an expense of a very few cents a bushel.

Inventions have changed the meaning of words. When I was a boy, a reaper was a man who reaped grain with a sickle, and a thrasher was one who thrashed it with a flail. Now, reapers and thrashers are machines driven by steam or horse-power.

For what part of our daily bread are we not indebted to inventions? Some of the fruits of the earth we eat as Nature gives them to us, but how much even of them do we take directly from the tree or shrub or plant which produced it, and eat without the aid of invention?

All our animal food comes within our reach and is prepared for use only by the aid of inventions.

Hooks and nets and spears give us all we have of fish. The fish-hook is a very simple contrivance. Is it a great invention or a small one? If the fish-hooks should all be suddenly destroyed, together with the ability to make them, would not the loss of the invention be a greater calamity than any which has befallen the world for a thousand years? If so, were not the inventors of that instrument, and those who have improved it, real benefactors to the world?

Could we get along without needles? Could we give up pins without a sigh? Are knives and forks and spoons a necessity? They are all among the simplest things that man makes, yet he has not obtained them without a great deal of mental labor; without the exercise of powers of invention of a high order.

It is less than fifty years since the little articles called matches have come into use. They are now so common and so cheap that we use them almost as we do air and water, without thinking at all of their real value. How few there are of us who do not use them every day and many times a day, and how inconvenient it would be not to have them! But, when I was a boy, nobody had them; nobody could have them, for they did not exist. In the country-houses, at least, the greatest care was exercised not to let the fire go out upon the hearth, because in such case it became necessary to send to a neighbor's, often at a distance, for a fresh brand. Every night the live coals upon the hearth were carefully buried in the ashes to preserve them alive for the morning. In spite of this precaution, the fire was often lost. I have been sent many a time, in such cases, to a neighbor's in a cold morning to get a burning brand to start the fire at home anew. Nobody now thinks of taking any pains to preserve a fire, for it is easier to start a new one with a match than to preserve an old one. A very common way of lighting a candle in the house when darkness came on was to take, with the tongs, a coal from the fire—wood-fires were then used—and blow it, applying the wick of the candle to it at the same time. Sometimes it could be lighted very readily, but oftentimes it

could be done only by the exercise of a good deal of skill and patience. A great deal of vexation and trial of nerves and temper has been saved to the world by the invention of matches, and the comforts of our homes increased in many ways. Perhaps, therefore, the comparison I suggested between friction-matches and Sunday-schools is not so incongruous as it may at first seem.

There were some devices known in those days for obtaining a light or fire artificially, but they were inconvenient, somewhat expensive, and not in general use. The tinder-box was one of them.

A gentleman not much older than myself told me not long since that when he was in college one of his classmates was rich in the possession of a tinder-box by means of which he could strike a light and a fire in case of emergency, and he gave me a humorous account of the process of striking a light, involving considerable skill, much patience, and, as he said, some swearing.

A great many boys have been taught in Sabbath-schools not to swear, but a great many more have doubtless, by the use of friction-matches, escaped numerous occasions and temptations to swear, and wives have no doubt by this invention been saved from innumerable scoldings for not covering up the fire properly at night.

There is one curious fact about matches which I do not remember to have seen mentioned. We speak of them as a recent invention, but they are only an improvement upon a very old invention. Travelers among savages have generally, if not universally, found that they possessed the art of procuring fire when they wished, by rubbing two pieces of wood together till the heat generated by the friction between them caused one of them to take fire. It is described as a pretty crude way of working, calling for considerable skill and some labor and patience. Perhaps the date of the invention may go back to the earliest use of fire by man. Yet the invention itself is essentially that which we practice when we strike a match. We rub the match upon another substance, and the heat generated by the friction between the two causes the match to take fire. The improvement which the civilized man has made upon the invention of his savage ancestor is to coat the end of a piece of wood with a little composition of matter which takes fire at a lower temperature than the wood itself, and burns more rapidly. Simple as the improvement is, it took the world a long time to get it, and its inventor made a most important contribution to the comforts of man.

I was forcibly impressed a few years ago with the value to the uncivilized man of the simplest inventions of the civilized man, as I watched an Indian at Lake Superior at work upon a birch-bark canoe. He had for tools only a knife, a hammer, and an awl, but I suppose he must have used a hatchet to procure the wood and bark of which the canoe was built. It was slow work even with these tools, and it was difficult to believe that he could have built the vessel with the

blunt instruments with which his ancestors had to be content before they came into contact with the white man. What an acquisition the white man's fish-hook must have been to the Indian!

Fifty years ago a large part of the people of this country had no other resource for artificial light than the tallow-candle. I remember it, and the vexations attending its use, the difficulty of lighting it by a coal of fire, the constant snuffing it required to make its light tolerable, and its constant tendency to melt and besmear everything in its vicinity. I venture to say that any of you would consider it an intolerable hardship to be compelled to use it and nothing else. Those who used oil-lamps got a little better light, but not much less discomfort. Gas was used only in the large cities. But the inventors have been busy in providing a new material for illumination and the means for using it and in cheapening their production; and now in kerosene and in kerosene-lamps, both of which have been called into existence within thirty years, the poorest people can enjoy, at the most trifling expense, a light better far than anything which anybody could command at any price before the invention of gas less than a hundred years ago.

Can we estimate the comforts of the homes of the country due to these inventions? Can we estimate the greater value of the evening hours for work, or study, or reading, which these inventions have given them?

I remember that my mother had a vial of what she called rock-oil, which she thought very good for sprains or bruises. It was said to have come from Western New York. I now suppose it to have been petroleum. Petroleum has been known to man for a long time, but it had no value till it came under the hands of the inventor. He has made a worthless article a blessing. Invention marks every step of its history. Petroleum in this country lies deep in the earth. By the aid of recent inventions man reaches it. By their aid he stores it, for it is a dangerous and difficult article to keep and transport. By invention, man has changed its character. And now, not only this country, but the whole world, is lighted by this new material. Yet all the invention which has been bestowed upon it would have been wasted but for another class of inventors and another line of inventions. The lamps had to be invented or improved, and hundreds of men have been engaged on their improvement for years.

And now inventors have entered a new field and given us a light for our homes and streets almost as brilliant as that from the sun itself, from that agent which, since the world began, has lighted up the sky in angry flashes only to alarm timid and superstitious man.

It is a curious and interesting exercise to take any common article of daily use and inquire how much invention has been involved in its production; what inventions have preceded it; what ones, if any, it has supplanted, and what ones it gave birth to; what consequences

followed its introduction, and what part it plays in the welfare of man.

The inquiry soon becomes a bewildering one.

Take paper, for instance. I believe we are indebted to the Chinese for its invention. Do we ever think of it as one of the great inventions of man? Why, it is nothing but rags ground up in water to a pulp, spread out in a thin sheet, and dried. I think the art of making paper has been known in Europe less than a thousand years. It has taken the place of parchment for writing. It made the art of printing possible. It made the newspaper possible, and especially the daily paper. The multiplication of pictures by engraving could not be carried on without it, nor the modern art of photography, to which I shall refer again. We attach great value to a system of general education as one of the most important agencies of modern civilization. But the first requisite of such a system is cheap books, and for these paper is the only thing we could use. Would any of you undertake to enumerate within the next half-hour all the uses to which paper is put? Would you undertake to name and describe all the kinds that are used?

Paper is largely made of rags. Rags presuppose the existence of cloth. Cloth is the product of two distinct inventions, spinning and weaving. Spinning and weaving are very old inventions, but even in their simplest form they involve the use of still older inventions. Whatever material is used for paper, a long line of antecedent inventions is involved in its use.

Paper must, I think, rank as one of the great inventions of man, and, if the heathen Chinese had given the world nothing more than this, he would have made no small contribution to the progress of civilization.

I have said that paper is made from rags, and that cloth implies the arts of spinning and weaving. But it also implies much more. To me, one of the greatest marvels of human industry is a yard of cotton cloth at the price at which it is sold. The price of a yard of cotton cloth of the kind called print-cloth, and which when printed becomes calico, is less than four cents, and the cotton itself costs half this sum. What inventions are involved in the raising of the cotton and its transportation to the mill where it is to be converted into cloth! Of course we all think of the cotton-gin, because that invention was made with special reference to the production of cotton, and has been much referred to as a striking example of the results which flow from an invention.

But the gin comes into use only after the cotton is grown. Of course the common agricultural inventions are used in raising cotton: the plow, the hoe, the machinery by which the plow is made, the arts of making iron and steel, including the machinery employed, the harness for the horse or mule which draws the plow, and the art of tan-

ning the leather of which the harness is made. Recently planting or drilling machines for planting the seed have come into use, and artificial fertilizers—the product of the chemist's art—and the mechanism for distributing it over the ground. Even after the plant has begun to grow and before it is ripe, invention must often be called into play to protect it from the ravages of insects, and not a few devices, mechanical or chemical, have been called into existence for this purpose.

The ripe cotton-balls are still picked by hand, though inventors are busy with the problem of picking it by machinery. It is gathered into baskets or bags, themselves inventions, to be transported by a cart, another invention, to the gin-house, still another invention, where it comes under the operation of the gin to separate the cotton from the cotton-seed.

Would you like to know what the cotton-gin has done toward making cotton cheap, toward enabling enough to be sold for two cents to make a yard of cloth? An acre of ground is expected to produce at least one bale of cotton, which weighs four hundred pounds or over. Before the cotton-gin was invented, a man could pick about four pounds and a half of cotton from the seed in a day; so that it took a man about ninety days to separate the cotton which he could raise on an acre from the seed.

Whitney invented the cotton-gin, and with it a man could separate seventy pounds. In other words, he could do the work in six days which before took him ninety days. The invention was made less than a hundred years ago, but inventors have been busy with it ever since, improving it year by year, and now it turns out four thousand pounds a day! In other words, a single machine will do the work of about a thousand men.

As soon as the cotton is through the gin it must be pressed into bales, for the cotton is a light, bulky article which can not be transported without confinement and a great reduction of bulk. So another invention is required, the cotton-press. Some of these presses are wonderful machines. They embrace a steam-engine, a force-pump, and a hydraulic or hydrostatic press, and give a pressure of 4,000 pounds to the square inch.

The cotton-bale is surrounded by a coarse cloth called gunny-cloth, itself the product of another line of inventions, including the arts of spinning and weaving, and made by special machinery. The bale must also be hooped with iron hoops, involving again the inventions pertaining to the manufacture of iron, but in addition the machinery for rolling it into thin and narrow strips, and I think this embraces the art of rolling iron into round bars and drawing it into wire.

These hoops must at last be fastened around the bales, and that has called for the invention of peculiar fastenings called cotton-bale ties.

At length, through all these inventions, we have the cotton ready

for market and transportation to the factory, where it is to be made into cloth.

This demands the use not only of the cart or wagon, an old but important invention, but the railroad, the car, and the locomotive or the steamship, or perhaps both of them. It is bewildering to think of the inventions involved in these, and I could not even enumerate them in the time I have, if I knew them all.

When the cotton reaches the factory, an invention stands ready to unload it from the cars and deposit it where it is to be used. The iron bands are removed by some instrument invented for the purpose, and the cotton is released from its confinement. It is submitted to machinery to free it from dirt and restore it to something of its original light, flocculent character, and it then enters a machine which spreads it out into a long sheet like cotton batting. This sheet in turn is stretched out into a long, soft rope, called a roving. Successive machines, four or five in number, I believe, extend the roving and make it smaller, till it is smaller than a common pencil. It then goes on to a spinning-frame and is twisted into a thread ready for weaving. Our two cents' worth of cotton has been drawn out into a fine thread more than 7,000 yards long, each inch of which has more than forty twists in it.

Shall I stop to tell you what man has achieved in the art of spinning? The art, as you know, is a very old one. Its invention lies back of the records of history. It was practiced a long time in its primitive form as a mere manual operation. The wool or flax or cotton was carried on a distaff. The thread was drawn out and twisted by means of a spindle held in the left hand, by which it was set to whirling while the fibers were drawn out of the mass and guided by the fingers of the right hand. The art was practiced in this crude way for ages, and it is so practiced now in some countries.

A book which describes this process says it was an obvious improvement to set the spindle in a frame and set it whirling by a band passed round it, and around a large wheel which was in revolution. But it was not so obvious that anybody, through long years, thought of it till about three hundred and fifty years ago. I believe this improvement which constituted the common spinning-wheel was invented in Germany. A woman could spin with it much faster than in the old way, but she only kept one spindle employed. A little more than a hundred years ago the spinning-frame was invented in England, in which a number of spindles were set and kept in operation at the same time. At first only eight spindles were used, but now several hundred are used in one frame.

There were three leading inventors at this early date who each made important improvements in spinning—Hargreaves, Arkwright, and Crompton. With a common wheel a woman can draw out a thread about four miles long in a day. On a modern spinning-frame

she can take care of 800 or more spindles and spin threads the aggregate length of which would be more than 2,000 miles.

On these machines cotton yarn has been spun so fine that one pound of cotton would make a thread 335 miles long, and as a feat threads have been so fine that a pound of cotton would reach nearly 5,000 miles!

To go back to our two cents' worth of cotton, which has been converted into yarn. It is subjected to the action of several machines before it reaches the loom, where it is converted into cloth. Weaving, like spinning, is old, and some sort of machinery has always been employed in the process, but the power-loom of our factories is a modern invention. I sometimes think it is the most wonderful machine used. To make one yard of cloth, a shuttle carrying the filling-thread is thrown across the web perhaps 1,500 times, at the rate of a hundred crossings a minute.

There are looms which weave cloth more than three yards wide. There may be nearly 10,000 warp-threads in cloth of this width, and 5,000 filling-threads in a yard carried across the web at the rate of nearly a hundred throws a minute.

The art of printing has always been recognized as one of the great inventions of man. It is over four hundred years old, but after its first introduction very little improvement was made until the present century. Since then it has presented a rapid succession of the highest efforts of mechanical genius. I shall not attempt to follow their history or describe their character; but it is interesting to know that they have been made almost wholly by English or American inventors, and that more has been done in this country than in England. The wonder of modern printing is that it can be done so cheaply. You have all seen the series of publications by the Harpers called the "Franklin Square Library." I bought a copy for ten cents, the regular price. It contained thirty-six printed pages. I had the curiosity to estimate the number of words on a page and calculated it roughly at 2,000. That would give for the whole book 72,000 words, all for ten cents. Can you form a conception of the number of inventions which has made such an achievement possible? I think a modern daily newspaper is, however, one of the greatest wonders of the age.

I buy a morning paper, the "Boston Herald," for instance, for two cents. I read it on my way to Boston in the horse-cars and abandon it at the end of the trip, not because it is worthless, but because I have obtained from it what I wanted and it will not pay to preserve it for any other person or for future use. Now, what do I buy for my two cents? The physical thing that I buy is a sheet of paper and a certain amount of printers' ink impressed upon the surface of the paper in the shapes of letters and words. It is a wonderful fact that man can spread out the fibers of various vegetable substances into a thin, uni-

form sheet like that of paper, that he can cover such sheet with signs which can be made to express every passion or emotion of the human heart, every conception of the mind, and every fact in nature! Scarcely less wonderful than the fact that he can do it at all is the fact that he can make such a sheet of the size of the "Boston Herald" for two cents. It would take a volume to record all the inventions which have been made relating to the manufacture of paper alone to make such a result possible, and another for the inventions relating to printing. But the inventions relating to paper and printing would not of themselves enable "Boston Heralds" to be printed. The "Herald" is not made and sold for the paper and ink of which it consists, but primarily for the news it contains of what has taken place only the day before all over the world. You will find in the "Herald," as you know, or any other morning paper, day after day, the news of what took place the day before, not in Boston or vicinity alone, or even in Massachusetts or New England, or in this country, but in Europe, Asia, and Africa as well.

Through the potency of modern inventions you may perhaps tomorrow morning shudder over the horrors of a railway accident taking place at this moment thousands of miles away. Not till within a short time, and only through the works of the inventor, did a railway accident become possible.

You may perhaps read that a palace of the Emperor of Russia has been blown down with dynamite. Will you stop to think that dynamite is a new invention, or that the telegraph which brings the news was unknown fifty years ago?

The paper may tell you that Mr. Edison has perfected his electric light and is at this moment illuminating many cities, and you will speculate upon the effect that the announcement will have upon gas-stocks, but will it occur to you that neither gas-stocks nor gas was known a hundred years ago, and that till within less than half that period man had but little more control of electricity than he has now of earthquakes?

Now, consider for a moment how this facility for transmitting intelligence must affect society in one of its most important aspects. A great calamity falls upon some distant city or community. If the news of it reached us, as it would have done a century ago, only after the lapse of days, or weeks, or months, and if friendly help can be given only after the lapse of a similar period, we may be touched with pity, but there will arise but little sense of sympathy or generosity or duty.

But when the intelligence reaches us almost at the moment of the occurrence of the event, and we are conscious that it lies in our power to help, the sympathies of thousands are awakened, their generous impulses are touched, and they recognize a moral obligation to bestow needed help, because it can be made immediately available. The duty

springs from the ability, and the ability is the fruit of invention. It may seem a strange assertion to many persons, but I believe it can be shown to be true, that the development of the moral nature of man has been as directly dependent upon invention as has his physical comfort.

[*To be continued.*]

THE MUSKET AS A SOCIAL FORCE.

By JOHN McELROY.

WHAT has always greatly puzzled the historical student has been to account for the debasement of the mass of mankind that took place during the long night of the dark ages.

In the lustrous afternoon which preceded that going down of the sun of civilization for a half-score of centuries the people of Europe seemed to be enjoying a fair measure of liberty and self-respect. In decaying Rome they were poor, for the wealth had agglutinated into the hands of the few. In barbaric Germany they were poor, because the wealth had not been created. But they were all free, and highest and lowest stood on a common plane of manhood. In spite of apparent caste distances, the substance of equality was yet a permanent and controlling quality. Everywhere the high and the low were but an arm's length apart, and the arm that measured that distance was a sturdy, manly one, usually quite ready to give and return blows. South of the Alps the proudest noble was within reach of the torch and dagger of the humblest plebeian. North of the great mountains no chief was so powerful as to be beyond the spear-thrust of the meanest of his followers. No man need be wholly abject, for he was always within striking distance of his oppressor. The turbulent Roman proletary resisted encroachment on his rights with riot and insurrection. The brawny Teuton knew no master but his elected chief, whom he deposed with scant ceremony the moment the leader's hand or nerve weakened.

A thousand years later, when day dawned once more, an amazing chasm was found to have opened up between the high and the low. The few were as gods in their power over the lives and property of the many. The low were as abject in their degradation as the beasts that perish.

In each community there had come to be one who lorded it like a wolf in a village of prairie-dogs. He dwelt on a hill-top, in a castle of massive masonry, clad himself in fine raiment, and gormandized, battened, and rioted. Where he was, there was "gude chere in knightlie hall," there were "wassail" and "revel" and "rouse" and all the other fine-named forms of the dull gluttony of feudal days.

In order that this one man might stale his palate with dainties, thousands of other men — "serfs," "churls," "villeins," "hinds," "peasants," etc.—were deprived of all but the smallest amount of coarse food that would enable them to live, labor, and reproduce their kind! In order that he might clothe himself in piled velvet, and his lady "walk in silk attire," they and their wives were confined to a single coarse garment. In order that he might sleep on down in marble halls, they were restricted to a couch of rushes in a fireless and windowless hovel.

Now, how did this man on the hill-top "so get the start of the majestic world" that all the kernels and sweetmeats in the lives of thousands were his, while only the rinds, the husks, and the shells, were thrown to them?

The answer is easy: It came about through the adaptation of the horse to warfare, and the development of defensive armor. Improvements in armor made the aggressive, domineering man invulnerable to spear and dagger in the hands of those whom he would oppress. Ensconced in tempered steel, and moved by a horse's mighty motive power, he was irresistible to those who could only oppose to him their own unprotected thews and sinews.

It is significant to notice how constantly the idea of the horse is associated with the elevation of the few and the degradation of the many under feudalism. In all the tongues of Europe it is the "Man on Horseback" who is the lord and despoiler of the people. The Germans called him "Der Ritter" (the rider), and cognate words designated him in all the divisions of the Teutonic speech. In French the horse is *un cheval*, and the tyrant of fields and people a *chevalier*. The Portuguese called him a *cavalleiro*, the Spaniards a *caballero*, and the Italians a *cavalliere*—all direct derivatives of the Greek and Latin *kaballus*, a horse. In England, where, for reasons that shall be given presently, the people were not crushed down to anything like the extent of their class on the Continent, the name given the Man on Horseback shows that he never acquired any such arrogant supremacy. There he was merely a knight (Anglo-Saxon *cniht*, a youth, an attendant, a military follower).

In the far-off days, ere the centuries had entered their teens, the gentleman who was burning with enthusiasm to earn his bread by the sweat of some one else's brows proceeded differently from what he would now. Contrasted with the neat finish of an "operation" in stocks or produce, or the Louisiana Lottery, his methods seem crude and clumsy. Nevertheless, like the methods of most of the processes of primitive people, they were quite effective.

He provided himself with a stout horse and a suit of armor combining all the latest improvements. He then set himself up as the lord and "protector" of as large a collection of land-tillers as he could cajole or force into accepting his "protection." Sydney Smith wittily

described a lawyer as "a gentleman who rescues your estate from your enemy and keeps it himself." It was on this principle that these "protectors" acted. They took the entire product of the husbandman's labor as a reward for their friendship and courage in protecting him from spoliation by some one else!

The period was the Golden Age of Might. It was the day of the absolute monarchy of Brawn, and the strong right arm was the court of first resort and tribunal of final appeal. Centuries of Egyptian, Greek, and Roman civilization had developed the science of jurisprudence into laws and customs which were fairly equitable in securing ownership of person and property. But moral chaos came again when the Gothic cataclysm rolled over Europe. There was no longer any recognition of a man's right to anything to which he could not hold on by main strength.

The gentleman whose factory-plant, office-furniture, and stock in trade consisted of a stone castle, a broad-haunched horse, a business-suit of spring-steel, and a twenty-foot lance, held thirteen trumps in the game as it was then played. To propitiate him—to gain even the privilege of living in unutterable wretchedness and squalor—freemen surrendered their lands to him, gave up all their labor's products, and even yielded to him such of their women as his momentary caprice might demand.

The Men on Horseback divided all the arable lands of Europe among them. Naturally they had hot disagreements as to who should have the monopoly of plundering a given valley or plain, and carried on the dispute with much clamor and fighting. In spite of the ornate descriptions of romancers and ballad-singers, this latter was not of a very sanguinary nature. So completely was armor finally made to answer its intended purpose that there are records of "battles" between imposing arrays of armored horsemen, which lasted all day, but in which not a single life was lost. The worst likely to happen to any combatant was that he be unhorsed, pinned to the ground by the weight of his armor, taken captive, and forced to pay ransom. "The knights of old" were warriors "for revenue only."

The only likelihood of any considerable slaughter was when the wretched serfs—goaded to madness by their wrongs—revolted against their despoilers, and strove against them with pikes, scythes, bills, and similar ineffective weapons. Then the wolf-hounds of murder were let loose. Cavaliers at war with one another would make a truce, to join in slaying "rebellious hinds." The last great battle of this kind was in the "War of the Jacquerie," in 1348, where nine thousand poor serfs were massacred in the French town of Meaux, and in the three weeks that the hunt lasted more than twenty thousand were slain. So fond were the chevaliers of this sport of hind-killing that it was not an uncommon thing for them—before or after one of the great armor-battering matches which they called battles—to turn upon and slaughter the

poor wretches whom they had mustered to attend them to the field. King Philip of France opened the battle of Crécy, in 1314, by charging his Genoese cross-bowmen with his chevaliers, and slaughtering them right and left!

The only men who resisted successfully these mounted ravagers and maintained for themselves some of the rudimentary rights of humanity were the merchants and artisans in the walled cities of Italy and Flanders; the Swiss, in their mountain fastnesses; and the insular English, whose dreadful long-bows would send arrows a cloth-yard in length through the best Milanese plate-armor. In consequence of the excellence of the English archery the Man on Horseback throve there so poorly that the worst condition of the English people in the middle ages was always better than the best condition of those on the Continent. Nor could the Man on Horseback's charge avail against the Italian and Flemish burghers, behind their solid walls.

In 1386 a horde of Austrian cavaliers, who were striving to reduce the Swiss mountaineers to serfdom, penetrated some distance into the Canton of Unterwalden. The ground was so rugged that they had to dismount, and proceed on foot. They were compelled to cut off the long toes of their shoes in order to be able to walk. They were suddenly confronted at Sempach by a small band of determined peasants. Arnold Struth von Winkelried performed his immortal act of self-sacrifice, by breaking with his naked breast the firm front of lances, and his companions rushed in and slew the clumsy dismounted horsemen. This and similar victories secured the freedom of the dwellers among the Alps, and bred there a race of men who were to become the flails to help beat feudalism to fragments.

With these exceptions the print of the war-horse's hoof was on every fertile acre in Europe. The long lance of his rider was the sickle which reaped the fruit of every man's labor. Greedier and greedier every year grew the hungry horde of steel-clad riders. Less and less of the comforts of life they left the abject peasantry. Nearer and nearer the condition of the laboring cattle sank those who delved and planted, and reaped and garnered.

The horsed harpies knew themselves well. They delighted in the character of birds and beasts of prey, and were proud to make lions, tigers, bears, eagles, and hawks, the cognizances by which they were known.

The sole mitigation of this reign of misery for the many was that, in spite of their armor, these rapacious harriers occasionally devoured one another. The strongest slew the less strong; the lions killed off some of the hyenas and jackals; the eagles tore to pieces the kites and hawks. The strongest and craftiest lord of some single hill-top killed off a number of his associates in the robbery business, or seized their lands after they had drunk and gorged themselves into the grave, and became lord of all the hill-tops commanding the entire plain or valley

—became a prince, duke, count, or margrave. The same process welded several of these principalities, counties, dukedoms, or marquisates into a kingdom. The advantage to the people of this was, that they had fewer masters to feed and clothe, and the exactions upon them had somewhat more system. Spain and France became the leading nations of Europe because this process of aggregation went on more rapidly there than in Germany, Italy, Austria, and elsewhere.

Progressive people everywhere saw clearly what an improvement a king was upon the Man on Horseback, and became his advocates and supporters.

If, however, there had been no brighter hope for mankind than was contained in the evolution from a swarm of petty tyrants to a monarch, the outlook would have been dark indeed. A millennium of that kind of progress would scarcely have brought mankind up to the plane occupied by the Russian serf to-day. Fortunately, another force was born into the world. Whether "black Barthel," the German monk, discovered gunpowder, or whether Friar Bacon preceded him, is of little consequence. The fourteenth century was yet quite young when *somebody* found out that a mixture of sulphur, niter, and charcoal would deliver a very heavy blow, and, as it was a day when heavy blows commanded the highest price of anything in the market, the attention of all progressive men was quickly turned to it. If we except the rhythmic beat of the vibrating battering-ram, the sturdiest blow then known was that which the momentum of a galloping horse delivered at the point of a lance. But even with the first rude tubes of wood and leather, or hooped iron boxes, the new force struck a blow that dismounted the doughtiest cavalier, and breached the thickest walls.

It began its work for mankind as the slave of kingcraft. Only kings could afford the costly "mortars," "vases," "culverins," "perriers," "falcons," etc.—only monarchs could employ the skilled artisans who manipulated these

> "... mortal engines whose rude throats
> Th' immortal Jove's dread thunders counterfeit."

It had to serve an apprenticeship to autocracy before it became democracy's mighty minister. It prepared the way for its future mission, even then, for kings used it to dismount cavaliers, and beat down their castle-walls. The despotism of the Man on Horseback began to crack around the edges, and in the rifts and fissures of the iron tyranny fell the mustard-seed that was to grow up into the world-shadowing tree of liberty. Its development was dishearteningly slow, however. It was a day when all intellectual processes were as slow as the pace of the overladen battle-horses, and invention crawled languidly, instead of running and leaping, as to-day.

So it was fully a century and a half after Ferdinand IV used the first cannon to aid in capturing Gibraltar, before we find a Man on

Foot using the first crude attempt at a musket. A favorite type of cannon were then called "bombards," and he styled this diminutive copy a "bombardelle." Nothing could have been ruder and more primitive in design and construction. It was merely a tube—probably about as large as a section of two-inch gas-pipe, but not so well made —with one end closed, and near that a small hole for a vent. It was securely fastened to a stout stick, the end of which rested on the ground to receive the recoil. The Man on Foot, clad in light armor, held the bombardelle up, while a comrade touched a live coal to the vent. Powder was as yet very weak, and it was necessary to use a ball weighing about a pound, in order to do any execution, even at the range of a few score paces. Nothing illustrates so well the amazing slowness of the evolutions of the heavily armored men and horses as that this clumsy weapon, which probably never had an effective range of one hundred yards, and could not have been fired oftener than once in five minutes, could have rendered any service whatever. With no facilities for aiming, it was by the merest accident that it struck the cavalier, unhorsed him, and put him at the mercy of his enemies on the ground, but even this chance was much gained.

The power was now getting into the hands in which it belonged. Invincible infantry means democracy sooner or later, just as inevitably as the invincible Man on Horseback meant aristocracy, and artillery autocracy. The foot-soldier, even though he be the myrmidon of a king or the henchman of a lord, is, unconsciously perhaps, the enemy of noble and sovereign. He comes from the people and returns to the people. Whatever he may do at behest of liege or lord is an object-lesson to his fellow-commoners as to what they may do in opposition. Every step taken by his masters to make him more formidable is

> "Bloody instruction, which, being taught, returns
> To plague th' inventor."

The first cavalier that was rolled in the dust by a bombardelle-ball reopened the era of the people which had closed when Rome's matchless infantry disappeared from the fighting world. Thenceforward the final overthrow of feudal and kingly despotism and the triumph of the people became merely a question of improvements in the bombardelle. In vain the Man on Horseback strengthened his armor and thickened his castle-walls. The stronger his armor, the more he was weighted down; the slower he moved, the longer he was within striking distance of the man with the "hand-gonne." Nor could the thickening of his walls keep pace with the improvement in cannon-making, the substitution of iron balls for stones, and the strengthening of gunpowder.

In those days the Germans called cannon "boxes" (Büchse), from the manner in which they were built up. They devised a fork or hook (Haken) to support the bombardelle and afford better aim, and called the improved arm a "hook-box" (Haken-büchse), whence the

various forms of "harkebus" and "arquebuse" in the different languages. Presently the tube, growing still lighter as the improvement in the manufacture of powder enabled the weight of the ball to be continually reduced, was laid in a stock similar to that of the famous Genoese cross-bow, and a priming-pan was placed at the vent. A little later a still more valuable improvement was made by attaching to the rear end of the barrel a piece of iron shaped like the letter S, and called a "serpent." The upper end of this carried the tip of a lighted rope-match into the priming-pan when the lower end was moved by the finger. When a trigger and springs were subsequently added, the Man on Foot had the historic "matchlock," with which he fought for two and a half centuries.

Thenceforward the march of improvement was steady and at an accelerating pace. The "hand-gonne" gained continual access of power over the Man on Horseback, and as continually its use became more familiar to the people at large. By singular concatenations, which some people are fond of terming "providential dispensations," the men advocating the best ideas got hold of the best improved guns and had the most of them.

In 1477 the Swiss, who had grown so self-confident that they did not hesitate to descend from their mountains to attack the Men on Horseback on the plains, came down from the passes of the Vosges Mountains carrying from six thousand to ten thousand of these firelocks, and at Granson, Morat, and Nancy, literally destroyed off the face of the earth the arrogant Charles the Bold and his rapacious Burgundian chivalry. Guns which combined the improvements of another half-century enabled the Spanish footmen to smite the French chevaliers hip and thigh at Pavia in 1525, where Francis I "lost everything but honor," and the Spanish infantry became the first in Europe, a position it held for nearly a century, until, as the instrument of ecclesiastical tyranny in the Netherlands, it was defeated by the superior guns and tactics of the Dutch infantry under Maurice of Nassau.

A few decades later the use of paper cartridges by the Swedish musketeers gave them an advantage which greatly aided Gustavus Adolphus to widen the horizon of Liberty by his successful warfare against the hordes of civil and religious despotism. Nearly simultaneously firelocks in the hands of Cromwell's superb foot-soldiery were preaching irresistible arguments on the Rights of Man to Charles I's cavaliers.

The mediæval Man on Horseback may now be said to have permanently disappeared from the field of battle. Granson, Morat, and Pavia had showed him of how little avail it was for him to cover every inch of his own body and that of his horse with the best steel, and he began stripping it off, to gain celerity of movement under the dreadful fire. By the end of the seventeenth century it was all gone but the helmet and breastplate, and these were not worn by him, but by

his mercenaries. As the musket now enabled battles to be determined by the superior manhood of superior numbers, and there was always a great deal of downright killing, he lost his keen interest in war as a business, and loved best to fight by proxy. The plaint of the fop to Harry Hotspur was an anachronism of about two hundred years for Henry IV's reign, but it expressed pretty accurately the feelings of the aristocracy in Shakespeare's time:

> "And that it was a great pity, so it was,
> This villainous saltpeter should be digged
> Out of the bowels of the harmless earth,
> Which many a good tall fellow had destroyed
> So cowardly; and but for these vile guns
> He would himself have been a soldier."

The Man on Horseback still continued to don his suit of "complete steel" from time to time for nearly a century after it was last worn in line of battle, but it was only to impress the popular imagination and enhance his personal appearance when he took part in the pageantry of government. The long warfare between him and the king had ended in his entire subjugation, and he was now an obsequious attendant upon "his royal master," with whom he had entered into an offensive and defensive alliance against the common people.

Steady improvement of the weapon through the seventeenth and eighteenth centuries, by the men who were wielding it to gain for themselves the commonest rights of ownership in their own souls and bodies and the fruits of their toil, had made the musket so handy that the cumbrous fork-rest could be dispensed with, and had given it the flint-lock, the bayonet, and the front-sight, which latter greatly increased the accuracy of aim.

By another of those remarkable providential dispensations, grim old Leopold of Dessau devised the iron ramrod, just at the time when it was most needed to enable the little Prussian army to withstand the overwhelming masses of barbaric Russia, stupid old Austria, and intriguing France. As Frederick II's men were able to fire five times to their enemies' twice, the reactionary waves beat in vain against the new bulwark raised up to protect the progressivism which had made its home in Northwestern Europe.

Across the Western seas a still greater development was taking place. In the grasp of the men who had sought refuge from tyranny in the wilds of America the musket was not the mysterious and awkwardly handled engine it was in the hands of most Europeans. To the colonist it was the most familiar of his every-day tools. The daily food of the family was provided with it; the fiercest wild beasts were slain by it, and the fiercer wild Indians were conquered by it and driven from the lands which they claimed as their birthright. Being its owner's main dependence in his struggle for life, he naturally

strove to raise its powers to the highest mechanical limits of the day. By rifling the inside of the barrel, and placing a sight on the rear end, he made his aim mathematically certain. With such a weapon he could encounter every mortal foe with entire confidence. Rattlesnake nor panther, wild Indian nor foreign mercenary, had any terrors for him. If his foe had brain or heart, his unerring bullet was sure to find it.

With his rifle in hand the common man reclothed himself with all the rights that had been torn from him by a thousand years of the despotism of the Man on Horseback. He brooked so little of tyranny that he would not endure so much of it as was involved in the attempt to tax him without his full consent. The assertion in the preamble to the Declaration of Independence differed from most similar fulminations in that it was not ahead but only abreast of the popular acceptance of the principles which it affirmed. Men were not only endowed with the inalienable rights of life, liberty, and the pursuit of happiness, but on this side of the ocean they exercised them to the fullest extent.

Still more: they taught the Frenchmen who had come here to assist them in their final struggle for freedom, by precept, and those who had stayed at home by example, that the musket was the means by which those rights were obtained and maintained. They demonstrated in practice the axioms to a perception of which all Europe had been slowly rising: that before the musket's muzzle all men are equal; that lordly lineage, boundless wealth, nor privileged caste can hedge a man with a divinity impervious to bullets; but that any set of men, who love liberty well enough to peril life for it, must be met on equal terms, with equal hazard of life, by those who would deprive them of it; that the reign of the few was ending, and that of the many beginning, for, with all men equally able to kill their opposers, only those governments and systems of governments can maintain themselves which can rally to their support more than can be arrayed in opposition.

In all the world's history no teaching ever had such immediate and tremendous results. Within a quarter of a century after the close of the American Revolution the new Evangel of Freedom had flamed from the Seine to the Moskwa, at the muzzles of millions of muskets, borne by men who had suddenly risen from the abasement of serfdom to the full stature of manhood. In France, the chosen home of chivalry, the degenerate sons of the Men on Horseback had been drowned in a sea of their own vicious blood. In all the fairest parts of Continental Europe the land had been wrested from the heirs of the banditti-lords, and restored to the ownership of those who tilled it. The whole civilized world had begun that rapid march toward popular government

> "· · · whose compulsive course
> Ne'er knows retiring ebb,"

but will "keep due on," until emperors, kings, and potentates will be as obsolete as the "tabards," "beevors," "brassards," and other trumpery of the mediæval Man on Horseback.

All life is battling—all society a conflict of forces. Little worth having is ever got without being wrung from the teeth of opposition. Particularly is this true of the ordinary possession of manhood. Every privilege and immunity which we enjoy to-day, without more thought than we enjoy the sunshine and the summer air, has been extorted—most frequently through bloodshed—from those who would fain withhold it. The student of history reading the Bill of Rights sees in every clause the result of some successful war fought to wring a concession of that particular principle from the dominant class. The musket has steadily led the way and supported every extension of the boundaries of freedom. Without so irresistible a weapon within reach of every man's hand, the world would still be prostrate under the hoofs of an equestrian aristocracy, whose despotism would only be tempered by the tyranny of kingcraft.

Artillery is monarchic, cavalry aristocratic, and infantry democratic. Armor and the horse brought about the rule of the few over the many; cannon helped make one man ruler over all; while the musket is the agent of the popular will and the pioneer of universal suffrage. "All free government," says an eminent philosopher, "depends upon the power of the majority to whip the minority." The fundamental principle of democracy is that the wishes of one thousand men shall prevail over those of nine hundred men, and the musket gives the thousand men the physical power to enforce their will upon the nine hundred men.

DISCRIMINATION IN RAILWAY RATES.

By GERRIT L. LANSING.

I.

THE term discrimination, in its application to railroad rates, seems in the minds of some to have lost its original and true meaning—the act of distinguishing between things which are different. In the general affairs of life, the ability to discriminate is as commendable as the lack of it is discreditable. There appears no reason why the reverse of this should be true when applied to transportation. There must always be differences which fairly affect rates, as competitive routes and markets, the bulk and value of commodities, and the volume of the traffic. These differences demand recognition and require discrimination in fixing rates; but there should be no discrimination without a difference. This would afford a profit to a favored few, but would effect an injury to the many, and is therefore unjust.

It is asserted by transportation companies that such discriminations as they practice result from the differences which exist, and, though they may sometimes cause an injury to a few, they effect a much greater benefit to the many. The difficulty in the question is right here: The decision as to what is a sufficient difference to fairly require a discrimination in its favor must be decided by the fallible mind of man. Differences of interest and so of opinion are therefore more frequent than differences of traffic. We may readily believe their statement, that the railroad managers are constantly besieged by the representatives of various places, trades, occupations, and interests, asking for concessions in rates that are not granted to others. Each claims some peculiarity of situation or circumstance which justifies some concession. It is natural also that most of these claims should be based on interest rather than on principle. The railroad manager is prone to this view, as the interests of the property under his charge are certainly not advanced by building up the trade of one place or person by giving lower rates than are allowed to others similarly situated. These differences of opinion, it seems, must always continue to exist as long as there are different interests in commerce and different circumstances affecting production and trade. The decision as to the differences, too, must always be made by man; and the government official in Germany, France, Italy, Spain, and other countries of Europe where there is state ownership of railroads, has caused even more complaint by his rulings than has the manager of the private corporation in the United States.

That discrimination may be fairly and legally exercised has been decided by the courts, while most of the States prohibit unjust discrimination. An act of the Legislature of Illinois of July 1, 1871, "was pronounced unconstitutional by the Supreme Court of the State, because in its operations it was not in express terms directed against *unjust* discrimination, but against discrimination generally." *

Such discriminations in rates as result from the operation of the railroads under the control only of the requirements of commerce and the interest of the corporations can not be unjust in the sense of political economy, can not affect injuriously the interests of the community at large, but, on the other hand, must always work for the advancement of the common good.

The causes of discrimination will be found in the principles regulating rates. That there are some natural principles is shown from the fact that in all the different parts of the world where railroads have been built the same questions arise from the dissatisfaction of communities, interests, and trades; the same charges of unjust discrimination are made, and the same remedies have been applied of legislative restriction and interference. To this we may add that there has been everywhere the same failure of these remedies to effect the result de-

* "Report of Railroad Commissioners of Illinois," 1876, p. 17.

sired. In the older localities the earlier rule of interference has been gradually withdrawn, as the common commercial law of self-interest has been found to produce the best results; and as the populations of newer communities have increased, their interests have become more established, and their experiences enlarged, they too tend toward the path followed by the older places. Italy, after an examination of the subject by a special commission, which was continued several years, decided to lease the Government railways to private corporations to operate. Switzerland, upon reviewing the experience of the other states of Europe, declined to exercise the right granted by the charters of the railway companies, that after a certain time the Government might purchase and operate the roads, deciding that it would neither profit the state nor benefit the people.* M. Léon Say says of the Government operation of the railways of France, "The failure is complete and irreparable."† And M. de la Gournerie, Inspector-General of the French Corps of Bridges and Highways, concludes a review of the subject of railway rates as follows: "I have sought to combat the widely spread opinion that, in the commercial operation of railroads, everything is artificial; that instead of observing, we must invent; that instead of habitually leaving the different interests to react upon each other through supply and demand, it is necessary to be regulating continually. If we were certain that the men who manage railroad business would always have a perfect understanding of these questions, my conclusion would be to leave the matter to them entirely; but the companies enjoy too great power for us to resign ourselves to endure tranquilly the consequences of their errors. I think, then, that the state should preserve its powers, watch attentively, but prescribe little."‡ The other countries of Europe have in general gone through similar experiences and arrived at the same conclusions, and, following the enlightened lead of the Railroad Commission of Massachusetts, the tendency in the other States of the American Union is undeniable also in the same direction of *laissez faire*.

In the transaction of trade, exchange is effected, not because one party demands it, but because both believe it to be a benefit. Neither can command what the other considers it his interest to refuse. Transportation is limited in the same way by the same requirements. The limit on one side is fixed by capital and is the *total cost of all the service performed*. If the roads are not able to secure enough traffic at prices which will pay the expenses of operation and a fair rate of interest on the investment, capital will no longer be invested in their construction. If they persistently fail to earn the ordinary expenses of operation, and so remain a constant tax upon the proprietors, they must ultimately be abandoned. The reduction of the charges can not

* "Herapath's Journal," London, April 28, 1883, p. 518.

† "Railway Age," 1882, p. 735.

‡ "Report of Commissioners of Transportation," California, 1877–'78, p. 73.

permanently be so low that the income is less than the expenditure. *The value of the service* to the shipper fixes the opposite limit to the reduction of charges. Here the rule applies to each shipment and at once. The shipper knows with considerable exactness the elements which enter into the cost of the commodity and the price it will bring in the market. He can at once determine then whether or not its transportation will afford him a profit. If it will, it is sent. If not, it remains where it is. With the railroad, on the other hand, the cost of no single shipment can be determined. It is carried on a freight-train, which also carries many other shipments consigned to many places. The same train often carries emigrant passengers, and is run over a track which is also used by passenger-trains. Besides these elements, there are large expenses incurred by the company of which an indefinite amount is chargeable to the various classes of traffic performed. It is thus a matter of impossibility to say what will be the cost of any particular shipment, and it is even a matter of extreme uncertainty to state the cost of the various classes of traffic each by itself —as passengers, freight, express, or mails. The only course then left to the railroad is to take the freight at whatever rate the shipper can send it with profit to himself and hope the whole of its traffic will amount to a greater sum than the cost of the service. The railroad may thus for years continue carrying freight at rates which do not cover the cost of the service, while the shipper will immediately stop his freight as soon as its transportation ceases to be remunerative to him. The rates can in no case be more than the value of the service, but they may be less than its cost. Between these two limits, the former of which ultimately determines the point below which no rates will be held, and the latter of which immediately determines the point above which no freight will be sent, there is in practical operation a varying scale of rates determined by competition both of parallel lines and various commercial forces.

These different kinds of competition I have elsewhere dwelt upon ;* it will answer the present purpose to name them. They are: competition of capital, of parallel railroads and water-routes, of markets, and the efforts of the railroad to increase its net income by increasing its traffic with lower rates. Wherever there is a fair discrimination exercised in fixing rates, it will be found to be based on one or more of these forms of competition. This proposition, it is intended to illustrate in the following pages ; and, if true, it is of the first importance, for, as competition is generally conceded to be a more potent regulator of prices than all other forces, if discriminations result from it, to prohibit them must also interfere with competition. All forms of discrimination in the rates of transportation which are fairly exercised may be classed under three heads—namely, those which favor persons, places, or things.

* "North American Review," May, 1884.

1. PERSONS.—Discriminations which are exercised in favor of persons in the transportation of freight will be found to be not in favor of the person but of the freight. In fact, personality has no part in it, but the concession is caused by the circumstances of locality or the kind or volume of the traffic. For instance, the farmers of the West and Northwest are systematically and greatly favored in the shipment of their products to the market. Grain and provisions are carried from Chicago to the seaboard at a discrimination in their favor of at least three to one as compared with the shipments by merchants, manufacturers, and others. But as without this concession the farmer would have no market for the greater part of his crop, and as it cheapens the cost to consumers of the staff of life, it is, though a discrimination, a subject of no complaint. The same remark applies to dealers in coal, lumber, petroleum, and all other things produced and consumed in large quantities.

But such rates should be open to all under similar circumstances; they can not fairly be affected by the personality. Where the circumstances of situation, kind, and quantity are the same, to give lower rates to one person than to another is, in most States, illegal as well as unjust. It tends, by preventing competition in trade, to maintain prices, and so to limit consumption and restrict traffic—a result directly opposed to the chief end for which all railroad managers are striving. I can conceive of no case in which a railroad would grant one shipper privileges not accorded to another where the circumstances of the traffic were the same, except it were as a gift and not in the line of a business policy; that is to say, the advantage given would be at the expense of the railroad.

In the transportation of passengers, however, differential rates are made which more nearly approach a discrimination as to persons. Yet, in this case too we will find that the different rates are caused by a difference in the traffic, and that, under like circumstances, rates to all are alike. With passengers, a discrimination based on the volume of the traffic results in the excursion rates, round-trip tickets, commutation, season, and one thousand-mile tickets, and the like, familiar to all. For instance, in California, from San Francisco to Alameda, Oakland, or Berkeley, a distance in each case of about ten miles, the passenger may buy a trip-ticket for fifteen cents, a round-trip ticket for twenty-five cents, and a sixty-ride ticket for three dollars, or at the rate of five cents a trip. The rate per mile would be, in the several cases, a cent and a half, a cent and a quarter, and half a cent respectively. Though here is a discrimination, in the proportion of three to one, yet its fairness is not only popularly conceded, but the Constitution of the State especially provides that "excursion and commutation tickets may be issued at special rates." The question, as popularly put, here arises, "On the ground of fairness, why should one person in the same train, between the same points, pay three times

as much fare as another?" The highest of these fares—a cent and a half a mile—is much lower than the average rate of fare charged in the United States or on the remaining portions of the same road. It is certainly not, then, unreasonably high. But the reason it is lower than in the average of cases is that the ordinary traffic between the points in question, excluding that at special rates, and the possibilities of its development, are sufficient to warrant it. As to the traffic carried at the special rates, it could not be obtained without the special concessions. And, the road being built and the trains running, the *extra* traffic may be carried at a fraction of the average rate of cost for the *whole*. There is thus a profit under the circumstances on this traffic at the special rates; and, as it is developed and increased by the concessions made in its favor, it helps to pay more and more of the fixed expenses which were in force before its existence, and so by relieving the regular traffic of a portion of its burden of expense makes possible also a reduction in its rates. The reason for the discrimination, then, results from its necessity to secure the traffic; the common reason in all cases of lawful and fair discrimination. If, by an equalization of these rates, their averages were established as the rate for the whole, the daily passenger who now pays ten cents a day for his fare from his home to his place of business in the city and return would then be compelled to pay twenty-two cents. It is certain that in the greater number of cases he would not do this. Now, with this suburban traffic, as with all other traffic, the rates decrease as the volume increases—other things being equal—and, as the rate of expenses per passenger also decreases under the same conditions, the differential rates are justified on the ground of the cost of the service, as well as from the necessity of the traffic. The very much greater portion of the suburban traffic is from the passengers who travel daily, a much smaller portion from those who purchase round-trip tickets, and the remainder from those who make an occasional single trip. The rates are thus inversely to the volume of the traffic. The highest *rate* is paid by those who pay very few *fares*, and the lowest by those who pay the largest number. This is a distribution of the burden of the expense which causes it to be felt the least; and it results in giving the benefit in the fares to those who by increasing the traffic cause the reduction in the rate of expense.

That the suburban passenger traffic throughout the United States is carried at lower rates than any other is a familiar fact, explained by the possibility of development and justified by its much greater volume, which is accompanied by a lower rate of cost per passenger. Where the volume of the traffic is less, the rate and the cost per passenger are alike greater. This rule holds good throughout, other things of course being equal. In the minority report of the Railroad Commission of California for 1883 (pp. 137–140), which is extremely hostile to the railroads of that State, it appears that the lowest pas-

senger rates exist where there is the greatest traffic, and that "between all the thickly settled portions of the State" the rates are considerably lower than prescribed by the orders of the commissioners. An appended table in the same report shows that during the year 1881 the principal railroad company in the State had forty-six stations from which no passengers were carried, sixty-two from which the daily average was from one passenger each two days to one in thirty days, and there were forty stations to which no tickets were sold. It is in these cases, the report explains, that the highest rates prevail.

It thus appears that the discriminations which may be fairly exercised as to persons are not affected by the personality, but by the traffic. Like rates under like circumstances to all is certainly the common rule in experience, and in nearly every State any violation of this is properly prohibited by law. The railroad takes no cognizance of the person, but exerts all its efforts toward developing the traffic. The passenger who pays a cent and a half per mile for a single-trip ticket may, if he chooses, buy a sixty-ride ticket at one third that rate. The possibility of development depends upon population; it is greatest between great cities and their suburbs, and least in the sparsely settled plains and mountains of the West.

The discriminations which are popularly supposed to favor persons in the transportation of freight, it will appear, are in a similar way caused by the traffic, and not by the person. Some of these depend on the difference between things, the remainder upon the differences in the situation of places.

2. Things.—There are some discriminations between things, the justice of which will at once be recognized, as there is an obvious difference between them. Light and bulky articles occupying an unusual amount of space should, if charged by weight, be charged at a higher rate than more compact things; fragile articles involve a greater loss to the railroad from breakage, which entails a greater average cost in their transportation; and valuable commodities being more frequently stolen, and as frequently lost, entail an extra rate to cover the insurance while in transit which is assumed by the carrier. But, aside from these obvious differences of bulk and value, which justify a difference in rates, there are other discriminations between things which will be found to be chiefly based on the volume of the traffic and the possibility of its development.

On examination we will find that the discrimination in these cases also is justified by a difference in the cost of the service. Large quantities are moved at a lower rate of cost per ton per mile than are smaller quantities. A car fully loaded to one consignee is carried at a great advantage over the same car partially loaded with small shipments to various persons; and train-loads running through with grain or coal, it will readily be seen, may be carried and handled at a lower rate per ton per mile than shipments aggregating an equal tonnage

switched off at various points and consigned to various parties. The Commissioners of Railroads of Massachusetts, in considering a complaint which was made on this ground of discrimination, not only justify the principle of quantity in reducing rates, but affirm that any other rule would be unjust. "One fact exists," they say, in reviewing a case, "which furnishes strong ground for criticism on the rates which are the subject of complaint. The Boston and Albany does not establish a lower rate for cargoes or large quantities than those fixed for car-loads. . . . The other great roads of the State do have one rate for car-loads and another and lower rate for cargoes, or for some large amount, generally fixed at one hundred tons. The principle on which this difference rests is founded on common sense, and is well recognized in railroad law; and it is recognized by the managers of the Boston and Albany Railroad in some other branches of traffic. Wholesale transactions furnish a reasonable ground for a reduction of rates; and, as the car-load rates of the Boston and Albany must be held as against that company to be reasonable as car-load rates, it follows that as cargo rates they are unreasonable." * This opinion is affirmed by the same company in their report for the year following, when in referring to the first case they say, "The meaning of the opinion was, that it was reasonable to fix a lower rate for large quantities than for single car-loads." † The principle here applied to cargoes and car-loads is generally applied to car-loads as compared to smaller quantities, and as the "car-load rate," though lower than the rate for smaller quantities, has been generally approved, it amounts also to an approval of the principle of lower rates for larger quantities.

The difference in rates on the same thing justified in the difference in quantity is generally charged by those shipping in small quantities to be a discrimination against them as individuals, and so as unjust. But we find a denial of this in the fact that the rule affects more frequently *things* which are shipped in large quantities than *persons* who ship large quantities of the same thing. Grain, provisions, and coal usually form the largest items of tonnage and have the lowest rates, and it is in favor of these things that the greatest discriminations are made. To deny the fairness of the principle would require not only that the various quantities should all take the same rate, but that things themselves should take the rates charged on other similar things which are shipped in smaller quantity. This is a result which some newspapers and politicians imagine would be beneficial; for instance, I read in a daily paper that it is an "outrage" that wheat is carried from the interior to San Francisco at a lower rate than castor-beans. But it is a result which, in the opinion of the Railroad Commissioners of Massachusetts, "would work mischief in some sections, would divert business from the State, paralyze industry, drive away capital, and injure our great interest—labor." ‡

* "Report," 1881, p. 212. † "Report," 1882, p. 100. ‡ "Report," 1883, p. 26.

The effect of free competition in trade is to bring the greatest competition to bear on those things in which there is the greatest trade. Thus, there is the smallest margin of profit over the cost of production on the necessaries of life, the next smallest on the common comforts, and the largest on the luxuries. This effect is not caused by any design on the part of traders nor from any beneficent legislation on the part of politicians. It results from the operation of natural laws of trade. The operations of the same laws produce the same effect on the rates of transportation. We find, as a rule, the lowest rates on coal, wood, petroleum, iron, lumber, etc.; the next lowest on flour, grain, provisions, etc.; we then have boots and shoes, cotton and woolen goods, clothing, etc.; and then a varying list of more costly or perishable articles and luxuries which are consumed in decreasing quantities. All the natural forces of competition which tend to reduce the rates of transportation co-operate in producing this discrimination in things which are moved in the largest quantities, and which are, of course, consumed in the largest amounts. The aim of the railroad manager is to secure the traffic. To do this he must make lower rates on cheap commodities, with those things which comprise the necessaries of life. It results in distributing the charges for transportation where they are most easily borne. Not only do the necessaries have the lowest rates and the luxuries the highest, but the necessaries consumed in the largest quantities have lower rates than those consumed in smaller quantities. We consume more fuel than bread, and more food than clothing, while the rates of transportation follow the opposite order.

This discrimination, though in favor of the necessaries and common comforts of life, is none the less a discrimination. It actually results in favoring classes. Those who consume but the necessaries, the day-laborers, are the most benefited; the artisans who consume, in addition to the necessaries, many of the comforts, the next; and so on as higher wages provide more of the comforts, and these merge into the luxuries. But the objection is frequently raised that the things having the lower rates are favored *at the expense of* the things required to pay the higher rates. That articles at low rates should be carried at the expense of things charged higher rates implies of necessity that the lower rates are below the cost, that the service is performed by the railroad at a loss. If the low-rate traffic is not carried at a loss—if the profit be ever so small—it can not, of course, be at the expense of the things paying higher rates. That the railroad should knowingly perform any part of its service at a loss is an absurdity, unless it be a case of nourishing an infant industry, where a temporary loss is incurred to secure a future gain. Those, indeed, who have been most forward in charging upon the railroads the fault of carrying part of their traffic at the expense of another part, would be the last to assert that the railroads are in the habit of doing a considerable part of their

service below cost. This charge is so frequently made, and the facts are so commonly misunderstood, that the subject deserves to be followed further.

We are for the present considering only the discrimination between *things* as determining the rate of their transportation. Discriminations from other causes do not change this result. Competition by other lines between the same points, or to the same market, produces a general reduction in rates, but there remains the same inequality in the particular things shipped. The lowest rates will be given on the staple products of the country which are moved in the largest quantities and higher rates on merchandise shipped in smaller consignments. For instance, the chief products of the West—grain, provisions, and flour—are shipped to the seaboard for about one half the rate charged on miscellaneous merchandise. And this is the same, whether the route be by lake, canal, or any of the various lines of rail.

One of the natural principles of regulating rates which has been mentioned is the power possessed by the railroad of increasing its net income by increasing its traffic at lower rates. This follows from the fact that a large portion of the expenses are fixed—are not changed by the increase or decrease of traffic; so that an augmented traffic adds to but a portion of the expenses of the roads—to those not fixed. The average rate of cost per ton per mile thus decreases, other things equal, as the traffic increases. This result will appear more definite by the use of figures. The census for 1880 * shows that the annual interest, maintenance, and operation charges paid at that time by the railroads of the United States, amounted to about the sum of $542,000,000, classified as follows:

	Amount.	Per cent.
1. Interest paid on debt †	$187,250,826	34·6
2. General officers, legal expenses, taxes, etc.	59,541,684	11·0
3. Maintenance of bridges, buildings, and way	85,722,748	15·8
4. Maintenance of engines and cars	54,985,340	10·1
5. Conducting transportation	88,230,621	16·3
6. Motive power—fuel, engine-men, etc	66,219,576	12·2
Total charges paid	$541,950,795	100·0

It appears from these figures that the fixed expenses of the average railroad in the United States, which are a necessary charge on whatever traffic is carried, are:

1. Interest	34·6 per cent.
2. General expenses, taxes, etc.	11·0 " "
3. Maintenance of way	15·8 " "
4. A portion of the maintenance of rolling-stock, which, if we assume to be one half, will be	5·05 " "
Making a total of	66.45 " "

* Vol. IV, "Transportation."

† By adding dividends paid, the item of interest would be considerably increased, giving a larger percentage to the fixed expenses and a smaller to be affected by traffic; but,

On the other hand, we have the remaining items which are directly affected by and vary with the particular kind or quantity of the traffic, namely:

Conducting transportation	16·3 per cent.
Motive power	12·2 " "
And say one half maintenance of rolling-stock	5·05 " "
Making a total of	33·55 " "

We may say in very general terms, but which are sufficiently accurate to illustrate the principle, that 66·45, or say two thirds, of the expenses of the railroad are unaffected, or affected in a slight degree, by the quantity of the traffic. With one train or ten trains a day two thirds of the expenses would remain without great change. By the increase of traffic the remaining one third of the expenses would be increased, though still not in proportion to the increase of traffic—as it costs no more for the wages of train-men, for instance, whether the cars are half-empty or all loaded to their full capacity.

An established traffic, then, which at the rate of one cent per ton per mile would pay all expenses, including interest on the investment, might be increased in volume with an increased cost of but one third of one cent per ton per mile. All in excess of that sum would be a profit to the company. So a lower class of freight at a rate of one half a cent, instead of being carried at a loss, or at the expense of the originally established traffic, would not only pay the additional expense incurred in its transportation of one third of a cent, but a profit also of one sixth of a cent per ton per mile. This small rate of profit multiplied by many tons may become a greater sum than the higher rate applied to its smaller tonnage. So it comes to pay a great part of the fixed expenses, and by relieving the higher-rate traffic of a portion of that burden allows reductions in the rates charged on that traffic which theretofore were not possible. The process continues indefinitely. Traffic formerly at higher rates is then stimulated by lower rates, with the hope of increasing its volume, and so of the net amount of profit in its carriage. New industries become possible where the former cost of the service on the movement of their products precluded their transportation. The principle which in the commencement led to a discrimination in favor of certain staple commodities, in the end results in reducing the rates on nearly or quite all articles composing the traffic.

The proposition, therefore, that the transportation of things at lower rates is carried at the expense of things at higher rates, though fair in sound, is false in fact. The error is in the assumption that all traffic is alike, that it is the same kind, quantity, and value. Remove these elements, and the proposition becomes a truism. Remove them, too, and the discrimination disappears. Or, if not, there being no dif-

as these figures are at best but approximate, the principle of the illustration is not affected, whether any item is either more or less.

ference in the traffic, the discrimination becomes then unjust. The fallacy of the proposition seems not to have been discovered by many who have been prominent in discussing the question of the regulation of railroad rates. I mean those who have taken a political rather than an economic view of the subject. Following a similar kind of reasoning, they have deduced the unreasonableness of higher rates from the existence of lower rates. "As," they say, "rates on grain, flour, or other things carried at low rates, being voluntarily fixed by the carrier, are presumably fair, it follows that rates not so low are unfair." Here, again, the traffic is conceived of as a mental abstraction which admits of no division or degree; it is always traffic—that is, always the same; while, as a matter of fact, there is a much greater difference in the things than in the discrimination. For, practically, instead of a refined classification, taking into account all differences of value, bulk, quantity, or destructibility, things which are similar in these respects, though not the same, are grouped together in a single class.

The enforcement of uniform rates on all the traffic of a railroad (making a difference only for bulky and perishable articles) is in practice a thing of the past, though with politicians it is still preached. It has, wherever tried, been found not only wanting, but destructive. In Belgium, as most of the railroads were owned and operated by the state, the uniform rate theory was naturally adopted, as upon the face it seemed to be the fairest plan. The effect was the restriction of traffic and the oppression of commerce. After this system had been some time tried, however, the cause of the restriction was seen to be the lack of discrimination in things, basing the rates upon bulk, weight, and destructibility only, and ignoring the fundamental principle—the value of the service.

The result of this experience is thus stated by the Commissioners of Railroads of Massachusetts:

"In 1856, in spite of a considerable increase in the miles of railroad worked, the freight movement of the Belgian railroads was found to have seriously decreased. Instead of making good the deficiency in receipts by increased rates on existing business, the administration met the emergency by accepting all traffic that offered, at greatly reduced special rates. This policy succeeded so well that, in 1861, the principle was adopted as regards minerals and raw materials of a regular low scale of charges, with a reduction according to distance. This resulted in the following year in an increase of 72 per cent in the tonnage of this class of goods. In 1862 the principle was extended to goods of the next class, with similar results. In 1864 freights were reclassified and the new principle applied to all except the first class, or small parcels which in this country are known as express matter. The result was summed up by the Minister of Public Works as follows: 'In eight years, between 1856–'64, the charges on

goods have been lowered, on an average, by 28 per cent; the public have sent 2,706,000 tons more goods, while they have actually saved more than $4,000,000 on the cost of carriage, and the public treasury has earned an increased net profit of $1,150,000.' A further reduction, made subsequently to this statement in 1864, exceeded even these results, and under it the tonnage rose from 4,479,000 tons in 1863 to 6,533,000 tons in 1864." *

In this country, an extract from the report of the railroad commisioners of a single State will illustrate the common experience as to the operation of the principle of discrimination in things. The Commissioners of Railroads for Alabama tell us: "A proviso of the first section of the act to provide for the regulation of railroad companies and persons operating railroads in this State, approved February 26, 1881, provides: 'That nothing in this act shall be construed to prevent contracts for special rates for the purpose of developing any industrial enterprises, or to prevent the execution of any such contract now existing.' Whether in pursuance of law, or for the development of their own business, it is usual for such railroad companies to concede such 'special rates' to these 'industrial enterprises' for the purpose of developing and building them up, such as factories, mines, lumber-mills, flouring and grist mills, gas companies, water-works, and other 'industrial enterprises.' These 'industrial enterprises,' as we have stated, have these special rates conceded to them very generally in the different States of the American Union. The products of the labor and skill of these 'industrial enterprises' are in many instances transported to distant markets, and the enterprises themselves are created for the purpose of such competition. Where this is the case, enterprises of this description in Alabama would not enter into this competition with those of other States unless put upon an equal footing with them as is done by these 'special rates'; nor could they maintain their business in competition with those of other States in the absence of such 'special rates.' And where these 'industrial enterprises' do not enter into the competition in other States—many of them do in Alabama—and in the absence of such 'special rates,' they would not be on equal footing to compete even in this State with enterprises of a similar character in other States, but doing business in Alabama. And in this class of these industrial enterprises where this competition does not exist at all, yet they furnish employment to larger numbers of persons, and confer public benefits in business upon the localities where they exist. It will thus be seen that in the two classes of these 'industrial enterprises' first above named, what would seem to be, to those not familiar with the facts, a special immunity given to them in these 'special rates,' and not accorded to the public generally, is, in fact, nothing more than putting them on an equal footing with similar enterprises in other States, and enabling them to fairly compete with

* "Massachusetts Report," 1870–'71, pp. 52, 53.

such foreign enterprises; while, in the third class, the State and community, as a consideration for the privilege allowed, receive a benefit which is general and permanent. Without such 'special rates,' few of these enterprises could be made profitable, and the most of them would have to be abandoned. We state these facts, for such they are, and not for the purpose of entering into any argument or defense of the system. We found such 'special rates' existing between the railroad companies and these 'industrial enterprises' in the State at the time we entered upon our duties, and many have been made between them since that time. We have examined these 'special rates' very generally and particularly. The railroad companies have furnished them to us for this purpose. We think that in general they are such as are well calculated to develop and build up these 'industrial enterprises.' We have examined them for the purpose of ascertaining whether there was in any of them any 'unjust discrimination,' in favor of any and against others of these 'industrial enterprises,' and thus far we have discovered nothing that can be fairly construed to come within this category. These 'special rates' are, of course, as various as the different kinds of business to which they relate. We have notified the railroad companies that, under the statute, they have the right to make any such 'special rates' of this character as may be agreed upon by them and any of these 'industrial enterprises' in favor of one and against another, and they have all uniformly adopted the same view of this matter. They are matters of contract in every instance, and therefore are not in such shape that they can be tabulated in this report."* The number of these pages might be indefinitely increased by additional quotations from the experience of Europe and America, illustrating the beneficial operation of the principle of discrimination between things in determining the rates of transportation. But enough has been said to show that the principle is based upon commercial necessity, and that under the operation of any other rule the railroad would fall far short alike of achieving its greatest usefulness to its patrons, and of yielding the largest profit to its proprietors.

ACCLIMATIZATION.†

By Professor RUDOLPH VIRCHOW.

IT is a well-known fact that the influence of a strange climate upon the emigrant, however little the new medium may differ from the mother-country in more or less essential qualities, exhibits itself at first in a kind of recrudescence of vigor, which, however, in a very

* "Alabama Reports," 1882, p. 28.

† From an address before the Congress of German Naturalists and Physicians, at Strasburg, September 22, 1885.

short time, sometimes after a few days, gives place to a general languor. Days, weeks, or months, according to the degree of healthfulness of the place, may pass before the organism is again in equilibrium; and this fact is so generally recognized that every traveler expects it and prepares for it. A person just landed in a distant country would be chargeable with imprudence if he neglected the precautions which experience has prescribed for diminishing as much as possible the inconveniences of this critical period. What does this mean? Simply that the organization of the new-comer must bring itself into harmony with the new medium. It makes no difference that he finds in the strange climate, in the European hotels, comforts, fare, and attentions so perfect as almost to make him forget that he has ever left his native land; he has, all the same, to go through the change which the climate works in his organism. He must adapt himself to it, become used to the new conditions. The fact of this process going on was known a long time before Darwin came into the world; and there is not, so far as I know, any doctor who has interpreted it in any other way than as a physical modification of the organism which is not limited to some superficial trait acquired by the transplanted person, but notably modifies the mechanism of the vital functions.

Two kinds of effects accompany the course of acclimatization: first, simple discomfort or climatic indisposition; and, afterward, illness proper or climatic illness. Danger, as distinguished from simple inconvenience, is the element that characterizes climatic illness. The invasion of the disease is real only in so far as the existence, or the integrity at least, of the whole organism is threatened. Till this moment, we have only indisposition to deal with; although, to speak accurately, illness and indisposition are not separated by clearly defined limits, but are rather two degrees of intensity of the same manifestation. A person is ill in the evening who was only indisposed in the morning.

If we review the vast literature that has accumulated on this subject, we shall be obliged to confess that original labors respecting these special modifications are almost wholly wanting. On the other hand, as soon as illness appears, the interest, which has now become immediate, excites the ardor of physicians; and they, by their numerous researches in this branch of the subject have given us knowledge, not only of what are generally the diseases of foreign regions, but also of their immediate causes. And, while there are still a few points in dispute, the increasing extension of wisely directed medical studies, at home and abroad, gives a well-founded hope that they will shortly be settled. Otherwise the condition of foreign medicine is but little different from that of our own; and there is no doubt that, with the progress of science, the clinics of tropical maladies will acquire an equally important development.

Our knowledge of the facts relative to climatic indispositions is not

what it ought to be, and yet there are some respecting which information is particularly important to us. Inasmuch as a transformation of the organism constitutes the principal element of a durable acclimatization, it is not the individual alone who is affected by a prolonged sojourn away from his native country, but his entire posterity as well. We can not, therefore, deny that this side of the question is the most important of all. There is one point of view from which the study of the transformations acquires a general interest of really vast extent. It is that of their relations with the history of the human race. Two questions occur at once to all who seek to arrive at a clear idea of the manner in which man has reached his present condition. Is it true that the different human races and varieties are issues from a common stock? And what are the causes of their diversity? It is of no use for our friends the zoölogists to preach transformism to us. That may do very well of itself when we have only an affair of building up a system. But, unfortunately, no man has ever yet observed the transformation from one race to another. No one has, for example, seen a people of the white race become black under the tropics, or negroes transplanted to the polar regions or to Canada metamorphosed into whites. The question whether color is related to climate still remains to be solved, experimentally at least; data bearing on the subject are still absolutely wanting. I confess that, if any one should ask me for the slightest light respecting the origin of races, I should not be in a condition to give a plausible argument or an experimental fact that would be competent to justify any point of view whatever. It is nevertheless true that, at the bottom of every impartial study of the phenomena of acclimatization, we arrive inevitably at the old point of view of Hippocrates, and that the existence of a relation between the somatic properties of man and certain geographical circumscriptions is not doubtful. That is what my friend Bastian understands by the term ethnological provinces. The reality of such provinces is incontestable; and they have the same significance with reference to man as zoölogical and botanical provinces in the geographical distribution of plants and animals. We can not deny that we have also the right to premise the existence of general laws of acclimatization which apply to plants and animals as well as to man—at least so far as regards the modifications of classes.

The prime question for us relates to the aptitude which the white man has manifested for acclimatization through all his historical evolution. To what point have we a right to conclude, from the data furnished by history, that the white man can find, outside of the limits of his country, conditions favorable to his existence? To bring up the vital point of the problem at once, the white man is not everywhere the same. Scientific experiment is every day tending to bring into more prominent relief the sharp differences in this matter which exist among the different subdivisions of the white race which we ordi-

narily include under a common denomination. Between the Aryan and Semitic branches, for example, the contrast is very clear. All the statistical documents and all the observations at large (*grands traits*) that have been made to this day go to confirm the greatly superior power of acclimatization of the Semitic to the Aryan peoples. The latter peoples may also be divided; and it is easy to separate those varieties with different aptitudes into geographical groups. The peoples of the south, the Portuguese, the Spaniards, the Maltese, and the Sicilians, are much superior to those of the north—so much so that the choice of one or another of these elements might be of decisive importance for the success of a colonizing enterprise.

In this may be found the solution of the controversy into which I have been drawn in the course of political debates. The fact is, that the history of the colonization of the Antilles shows us that, in the French and English establishments, the results of colonization have always been disastrous for immigrants from Europe, while in the Spanish colonies the results have been relatively favorable, although not so favorable as my adversaries have wished to make them appear.

These general observations must not, however, be accepted without reservation. They as yet represent only the starting-point of the discussion which it remains for us to bring to bear upon two capital questions. The first of these questions is concerning the opinion, which seems at the outset extremely plausible, that immigration into regions near the tropics, or even under the tropics, is nearly harmless to peoples who are natives of southern latitudes. Nothing is further from being proved, as we may see by referring to the negroes, whom it is very difficult to remove safely from one tropical country to another. The French in Senegal have had sad experience of this fact, and have seen death make terrible ravages among black populations which they had transplanted from their native land.

Another consideration that it is important not to lose sight of is that the farther south we go the more have the Aryan branches been exposed to foreign admixtures. The Maltese race, for example, exhibits a much superior resistance to the Sicilian or the southern Spanish race. We might be tempted to explain this by the insular situation of the former race, and by the character of the climate of its country. In that case the Maltese, transported to the African Continent, for instance, to a considerable distance from the coast, having come out from a climate distinctly insular, might be supposed to feel the change more profoundly than a Spaniard coming from his more continental climate. But nothing of the kind takes place. Algerian statistics establish most positively that the Maltese constantly holds his overwhelming superiority in adaptability over the Spaniard.

So the explanation of the special power of resistance shown by this race can not be based entirely upon an agreement of the climate of its native country with that of the place to which it emigrates.

There must, then, enter into the account some favorable circumstances derived from the mixture of foreign blood which it carries in its veins. This foreign blood is chiefly Semitic. As is well known, the Phœnicians, a people having more than one point of analogy with the maritime powers of our own days, were the first colonizers known in history. The Phœnicians were Semites; and archæological traces of their establishments are still to be found in Malta. They founded Carthage, and covered the Spanish coast with colonies, which probably extended for a considerable distance into the interior of the country. As the latest archæological researches prove, they colonized a good part of Greece. Their influence was so great, and their extension was so wide, that it would have been very strange if they had not contracted in Spain and elsewhere numerous family connections, and thus made their blood participate in the development of the races which have survived them in those countries. In less ancient times, most of the Iberian Peninsula was for hundreds of years in the power of the Arabs, or rather of Moors from Africa. These conquerors, who founded large cities and peopled entire districts, so that the Valencian garden and the valley of Granada still retain their Moorish aspect, who, in short, spread themselves over the whole country, undoubtedly left a numerous posterity behind them. And as the Spanish language is full of Moorish reminiscences, and Arabic words still adorn its vocabulary, how can the nation count the descendants of those Moors who hide their Semitic origin under Spanish names?

The race which now peoples those countries is, therefore, a mixed one; and there is no nation, even to us Germans, that has not furnished its quota to it. The Visigoths passed through Spain. They were dissolved there, and so completely absorbed that not a vestige of them is left, except, perhaps, in the institutions in which the most eminent Spaniards acknowledge, not without a feeling of gratitude, the contribution of Germanic genius to the development of their nation. Thus, from this fusion of Ibérians, Phœnicians, Moors, Romans, Celts, and Visigoths, to which may be added, perhaps, a few other German elements, such as the Alani, has risen the modern Spanish people, a mixed people, in the elements of which the pure Aryan race enters in part, but is nowise preponderant. If, now, we should undertake to say, "Wherever a Spaniard can go I can go too, for the same blood flows in the veins of both of us," we should be in great error. No; Spanish blood is not the same as flows in our veins; no more than is the blood of the Hindoos of to-day, with whom we have but lately tried to make a common ancestry, but whom no one now regards as a primitive race. We now trace our affiliation to that people which, coming down from the north, was crossed, higher classes and all, with the people that occupied the peninsula long before the arrival of the conquerors, and who were black.

There are, then, mixed races, to a certain extent more mixed than

we can observe among ourselves. It is, nevertheless, indisputable that, compared with the races in which the Aryan element has been observed in its purity, those races, especially those which have drawn largely from the Semitic fountain, are incomparably more fitted to acclimatize themselves, and propagate themselves in the midst of the new conditions in which they are placed in hot countries. In order to include under a more characteristic denomination those races which are only slightly refractory to the morbid influences of the climate, races to which we ourselves belong, I proposed, on a former occasion, to call them vulnerable races. This figurative expression might serve, in the domain of pathological ethnology, to designate the property which those races have of going through grave alterations under the influence of relatively slight external causes; and, considered in the narrower domain of acclimatization, the facility with which, among them, indisposition puts on the aspect of real illness. There is, however, a very limited zone within which these vulnerable races can implant and propagate themselves with comparative security. North America holds the first place in this favorable zone. Here we see the curious phenomenon of the French in Canada, the same northern French who are melting like wax in the sun of Algeria, becoming, from the little colony which they were in the beginning of the century, a vigorous and numerous people, and lively enough to hold their own against the rising tide of English immigration; while tens and tens of thousands of our countrymen, whom America receives annually at her ports, disappear in a very short time. In Canada, the colonists of French origin, animated by the most lively spirit of independence, have constituted themselves a people apart, and the last conflict, which has just closed, is a convincing proof of the tenacity of their national feeling.

Then comes the United States, with its vigorous and constantly increasing population. However much it may be mixed, it will always be Aryan at the bottom, for all the heterogeneous elements are absorbed, almost without leaving traces of themselves, in that immense hearth of colonization, which has no parallel in history. The English have been no less happy in the settlement of Australia, a colonization the energetic expansion of which has not been checked except toward the north, where the conditions grow unfavorable as the settlements approach the equator. Hence it comes that, in the northern part of Queensland, European colonists are not in a condition to endure the fatigue of agricultural labor. This fact has had much to do with the efforts made of late years to annex New Guinea and New Britain, whence it has been proposed to draw the manual forces required for the tillage of the soil.

In the South African colonies the Dutch have been solidly established for some two hundred years; and, in a few countries of South America, colonies composed of peoples of various European origin have

prospered, though unequally. There are also some young colonies founded by Germans on the Rio Grande, in Brazil, which a fancy still needing confirmation has placed in the rank of healthful countries and suitable for our people. Reviewing the results that have been obtained in the colonies thus briefly enumerated, which embrace the sum of the more or less fortunate enterprises of the kind, we see that their success has been in inverse proportion to the difference in isothermic latitude between them and the mother-country of the colonists. But in every case it is not probable that the organization of the colonists has escaped having to pay, at the expense of profound alterations, for acclimatization in foreign countries. Men of science, as well as tourists, have been interested for many years in the study of the Yankee type, which, according to the general opinion, is not wholly comparable either with the English or the German, or with a cross of the two with the Irish race. The peculiar physiology of the Yankee is yet to be made out, and I can not insist too strongly on the great value of the scientific results that might accrue from the study of this delicate ethnological problem. It is averred that the transformations of this type grow more pronounced as we go from the Northern to the Southern States.

It sometimes occurs that a population transplanted into a distant country remains apparently stationary. Nothing seems to distinguish it from the compatriots which it has left in its native country. But, on regarding it more closely, we find that there is operating within it one of the gravest phenomena in the history of colonization—a phenomenon which has been long observed in animals and plants when transported to new climates: a decrease of fecundity and an arrest of development, going at length to the complete elimination of posterity. It is evident that the condition most essential to the prosperity of a colony, the only guarantee of its longevity, resides in the number of children in the families of the settlers; children who, in their turn, the source of posterity, lead, as at home, to the branching out of every family into numerous ramifications. The further we advance into exotic climates, the more rapidly does the diminution of the reproductive faculty of the colonist go on, the more do statistics indicate a reduction in the number of births and an increasing sterility in successive generations. This fact has been noticed not only by doctors, who have called attention to it from time immemorial, but persons also who could have no prejudice in the matter—statesmen, military men, literary men, and men of every profession and every country, and those who lived in times when the question had not yet begun to be the order of the day—have observed for the most diverse countries that families formerly fertile, but who contracted alliances exclusively with natives of the exotic countries, lasted only a few generations.

It has never been possible, even to this day, to establish a durable colonization in British India. It has, indeed, been said recently that

it is possible, by means of severe hygienic processes, successfully to bring up an English generation there; but to do this the children have, as soon as they are able to support the journey, say at five or six years of age, to be taken to the mountains and left there till they are fifteen or sixteen years old. This reminds me of the palm-trees which we succeed in making bear fruit in our gardens. Because, by the use of the most elaborate horticulture we can occasionally cause a plant of the most delicate species to mature its fruit, shall we venture to regard the palm-tree as acclimated in our country? No more can we assert as much of a population which has no chance of maintaining itself except by taking all its children to the mountains and not allowing them to come down thence till they are mature men. A curious kind of family life that, and extremely costly if it were undertaken, the results of which are limited to bringing down the young generation, which is destined to live in the country, from the north to the south, from the mountains to the plain, like the ancient kings of Persia. But the indefatigable perseverance which has been applied for years in organizing this system does not in any way look to the colonization of India. It only seeks to create a new higher class, an aristocracy, which shall be better qualified to govern the country than annual new arrivals from England. I will also observe that the Dutch in Java and their other Eastern establishments have not advanced the problem a step. Every considerable family endeavors to send its children as soon as possible not merely to the mountains, but to Europe, more for physical conservation than for education. As a whole, these attempts at colonization singularly remind us of the fate of the Lombards in Italy. Those people, it is true, survived a little longer on the conquered territory; but very few centuries were sufficient to reduce them to the state of hardly appreciable vestiges. And for the Goths, it did not require a hundred years to annihilate them completely in that same Italy. Minute statistical researches have, it is true, quite recently brought to light here and there a few traces of the Lombards, and it is in a similar way not improbable that there may still exist in the country a very little of the ancient Germanic blood; but in upper Italy there does not remain any well-defined posterity; and in the northern provinces of Portugal and Spain, where the Visigoths reigned in all their power, it would be just as useless to look for any clearly appreciable posterity of the conquerors. I was recently accused of not being willing to range Italy and Spain among the countries favorable to the settlement of families originating in the lands of the North. I am sorry for it, but I can not perceive any facts that make it probable that our countrymen can settle in those states with any expectation of leaving an enduring posterity. I am ready to bow to the proof when it is brought forward. I would also suggest to our physicians of the navy and the merchant marine, and to all who travel for any purpose, that it would be a profitable task to prepare in the most sci-

entific form, and the one most fitted to aid investigations, the existing data bearing on this point.

What, then, to be precise, is the evil which threatens colonial populations, at first sight so little different from our own, and of which no external sign is apparent to reveal very profound transformations? The most powerful agent in producing degeneration, and to which doctors always give the first place, is the reduction of the formation of the blood in the organism. Is there really a retardation of this function, or an exaggerated destruction of the blood? I can not take the responsibility of deciding. Whatever it may be, emigrants are attacked with the same affection as in its phase of complete development among us is called anæmia. The more existence is tried by debilitating influences, the more intense becomes tropical anæmia.

But important as is its part, these debilitating influences do not consist of malaria alone, with its accompaniments of intermittent and other pernicious fevers, dysenteries, and liver-complaints; for even those whom the fever spares are not protected from tropical anæmia. The microscope has revealed to us many other morbid agents. Worms swarm in the tropics, particularly in the water, from which they pass to the body of man; and some of them abide in the blood. All such parasites may become destructive agents to the economy, which is subjected to a decline, the first manifestation of which is always impoverishment of the blood. With all our knowledge of the physiology of the blood, we are not yet able to explain, on the ground of merely theoretical data, the enormous loss of that liquid. We may admit that the preponderant part belongs to the destruction of the blood, while the absorption of air and oxygen is not increased.

A remarkable symptom, which is very well explained by an active destruction of the blood, is the strong predisposition to liver-disease. The liver is an organ the relation of which with the physiology of the blood is very intimate, and the troubles of which have the most influence upon the constitution of that liquid; and that is the organ which is the first object of the attacks, not only of malaria, but of the common diseases of acclimatization.

If I linger on these examples, it is to render more moving and more convincing the appeal which I make to doctors and naturalists to apply themselves to this sphere of research. Neither the French nor the English have as yet done anything important with reference to it. It is, then, a virgin field that falls to German science. It is also a subject of the highest importance; for we can not think of even an approximative solution of the problem till we have gained a precise idea of the modifications of the organism, and particularly of the special alterations of each organ, which are connected with the phenomena of acclimatization.

The popular masses, in their carelessness, seek the acquisition of gold. Show it to them, and they will plunge into perils without con-

cerning themselves about the rules of acclimatization and its diseases, any more than a starving man asks about the sanitary qualities of a ham that is offered to him.

The question before us is not of an isolated enterprise, but of very extensive ones, and is of interest to the empire as well as to the great companies which are lending their aid to emigration. Great problems must be resolved, in order that we may in the future be in a situation to inform our colonists respecting the fate which awaits them, to found colonies with a foresight of what the probable results will be, and to send emigrants into distant countries under the choice of circumstances which will permit them to hope for an assured existence.

These are questions which no general, war minister, or statesman has a right to evade. Why should it be different with those at whose invitation battalions of emigrants leave their country? There is New Guinea, with its rich plains and immense forests coming down to the river-banks. It is no longer a question of sending there only specialists to discover the most profitable timber-trees and then found business establishments. Just as in the last century, when the French desired to colonize Cayenne; what beautiful descriptions did they give of the fertile country, with its luxuriant flora, its wonderful forests, and its ravishing prairies! When the thousands and thousands of colonists who were sent there had perished to the last man, the French settled down to admire the photographs of those wonderful forests and stay quietly at home, leaving to those whose ethnological province is in Cayenne the task of propagating themselves and attending to their affairs. I have no doubt that we shall soon be forced to follow this example, and I hope that the frankness with which I declare this conviction will prompt us all to fulfill the duty which this great popular movement imposes upon naturalists and physicians. It is our duty to take hold of the question and organize the study of it, and to arm ourselves with scientific methods for the exploration of these distant countries, and for ascertaining to what point a permanent colonization in them is possible.

We need more than isolated examples to satisfy ourselves of the adaptability of the white race to fix itself in this or that place. A peculiar population exists in the mountainous region of the Island of Réunion, called "*petits blancs*," or little whites, who have been ascertained to be the last remains of the French colonists who established themselves in that part of the island a great many years ago. Recently a French traveler discovered in the Vindhya Mountains, in India, some survivors of a French colony which was founded there three centuries ago. There is nothing impossible in these facts; but they singularly remind us of the exotic conifers which are planted in our experimental forests. Now and then a forester has a success with one of them, and the little plant becomes an object of curiosity to travelers and the people of the neighborhood. But the number of

these plants is insignificant. They are isolated examples or rarities, and no particular importance can be attached to them.

All these facts, I repeat, only make us feel more keenly how desirable it would be to determine scientifically the conditions which make the existence of our vulnerable race on a foreign land possible. We might then direct our emigrants with the same certainty as that with which a modern captain, who knows their wants, provides for his troops. As I look at it, I can not regard the mission of naturalists and physicians toward their nation as conscientiously performed till a satisfactory solution is given to this problem.

INSTINCT AS A GUIDE TO HEALTH.

By FELIX L. OSWALD, M.D.

SINCE the beginning of the sixteenth century, when the clouds of the middle ages were broken by the first sun-glimpse of reawakening reason, the average longevity of the North Caucasian nations has increased nearly seven years. In Northern Europe and North America the progress in the practice, if not the science, of healthy living has, indeed, kept fairly step with the general advance of civilization; the worst heresies against the health-laws of Nature have become errors of the past. Unventilated dwellings have become unpopular. Phlebotomy has gone out of fashion. We have ceased to fuddle our children with beer-soup. Hygienic reform has everywhere modified our habits of life.

Yet the principle of that reform has strangely failed to be recognized. For one invalid who can steer a straight course to the harbor of health, a thousand weather the breakers in a random, empiric way, like untrained sailors, failing to comprehend the purpose of the beacon, though using its light to avoid the nearest cliffs. Nay, if the source of that light were indiscreetly revealed, it would frighten hundreds back into utter darkness, to scan the firmament for a glimpse of its vanished loadstars, rather than trust their safety to an earthly guide. For, with the progress of a practical regeneration, a theoretical adherence to the traditions of the past still goes hand in hand. Not all civilized Buddhists have renounced the Dalai Lama; and many of our progress-loving contemporaries would be rather alarmed at the discovery that the principle of our social, medical, and educational reforms during the last two hundred years has been a *restored trust in the competence of our natural instincts.* So foreign was that rule of conduct to the moral standards of the middle ages that its importance was recognized only in its apparent exceptions, the supposed "evil propensities of our unregenerate nature," such as poison-habits, sloth, and sexual ex-

cesses. The real significance of such aberrations would reveal the difference between natural appetites and abnormal (artificially acquired) appetencies, and teach us the necessity of applying the tests of that distinction to all persuasive instincts, and occasionally to otherwise unexplained aversions.

But even within those limits a critical study of our protective intuitions would surprisingly show in how many respects the hygienic reforms of the last two hundred years could have been anticipated by the simple teachings of our senses. For the wards of instinct a temperance sermon would be as superfluous as a lecture on the folly of drinking boiling petroleum, for to the palate of a normal living being —human or animal—alcohol is not only unattractive, but violently repulsive, and the baneful passion to which that repugnance can be forced to yield is so clearly abnormal that only the infatuation of the natural depravity dogma could ever mistake it for an innate appetite. In defense of the respiratory organs, Nature fights almost to the last. The blinded dupe of the night-air superstition would hardly assert that he finds the hot miasma of his unventilated bedroom more *pleasant* than fresh air. He thinks it safer, in spite—or perhaps because—of its repulsiveness. "Mistrust all pleasant things" was the watchword of the mediæval cosmogony. Long before Jahn and Pestalozzi demonstrated the hygienic importance of gymnastics, children embraced every opportunity for outdoor exercise with a zeal which only persistent restraint could abate. Sexual aberrations are a consequence, oftener than a cause, of disordered health. Instinct has always opposed the abuse of drugs, the delusions of asceticism, the suicidal follies of fashion. Instinct has never ceased to urge the reforms which our times have at last reached by such circuitous roads, and the study of its pleadings and protests might shorten those roads for the leaders of future generations.

On the other hand, it must be admitted that perverted appetites can become as irresistible as the most urgent natural instincts. Nor can it be denied that in some exceptional cases Nature fails to advise us of perils which her warning could easily avert, though we should remember that her standards of expediency are not always our own, and that, as a rule, instinct asserts itself at the fittest times, and with an urgency proportionate to the importance of its mission.

The exceptions, thus far only partly explained, may be summed up under the three following heads: 1. PERVERTED INSTINCTS.—The physiology of certain abnormal propensities is as obscure as the origin of sin. There is no doubt that the innate aversion to any poison known to modern chemistry can, by persistent disregard, be turned into a morbid appetency, *vehement and persistent in proportion to the virulence of the poison.* The most plausible hypothesis suggested in explanation of that fact seems to be the conjecture that, in adapting itself to the exigencies of abnormal circumstances, the constitution of the

organism has to undergo certain modifications, considerable in extreme cases, and correspondingly less easy to undo. For every "second nature" is, probably, a compromise with the persistency of untoward conditions. Iron-workers become less sensitive, and at last rather partial, to the fervid temperature of their workshops. Butchers, like the North American Indians, and other *carnivora*, are apt to contract a disposition which enables them to pursue their sanguinary vocation with callousness, or something akin to satisfaction. Slaves become sneaks, i. e., amateur flunkeys. The love of light, too often punished with *autos-da-fé*, becomes a love of dusk, if not of darkness; the Arian skeptic subsides into a resigned Capuchin—Nature forbears to maintain a hopeless struggle. For similar reasons, perhaps, she yields to the persistent infatuation of the self-poisoners, called topers and opium-eaters. Further resistance would imply chronic sea-sickness, and, under the circumstances, an abnormal fondness for strong drink may appear a lesser evil. Yet the characteristics of such propensities distinguish them clearly from a natural instinct; they have to be artificially acquired, their importunity knows no limits, and their free indulgence is always followed by a depressing reaction. Thus, even in yielding, Nature remains true to her preordained laws. No one can hope to evade their self-avenging rigor, though the mode of retribution may take the unexpected form of chaining the miscreant to his idol.

2. Abnormal Perils.—The dangers incident to our artificial modes of life seem now and then to deceive the foresight of instinct in a way typified in the non-repulsiveness of certain mineral poisons. Nature has taken ample precautions to secure her creatures against the poison-perils of the upper world—hemlock, foxglove, and belladonna—but failed to provide safeguards against such subterranean evils as arsenic, or the social dangers yet slumbering in the womb of Time. Providence, however, may have foreseen that perils evoked by the potent hand of Science could be avoided in the same way; though the struggle for existence may, in the course of time, evolve supplementary instincts. Those fittest to survive, methinks, already begin to evince an intuitive aversion to the sugar-coated poisons that have reduced our average longevity to less than forty years. The world is getting prudent by natural selection. The children of the twentieth century will not be apt to overrate the nutritive value of fusel-oil.

3. Parasitic Disorders.—The healing instincts of Nature, which teach the surfeited brute to abstain from food, somehow fail to take cognizance of the disorders caused by the agency of microscopic parasites, entozoa, etc. It has been suggested that the development of such organisms is as foreign to the *autonomy* of the human system as the growth of the mistletoe is to that of the oak, and thus escapes the jurisdiction of its self-regulating laws. But a still more suggestive circumstance is the fact that disorders of the class named reveal their origin plainly enough to permit a direct removal of the cause, which,

in other ("symptomatic") diseases, is often aggravated by the suppression of its external manifestations. In other words, Art is here competent to deal with the hostile "power behind phenomena," and Instinct resigns its mission to Reason.

It is still a mooted question if tuberculosis can be included among the "germ-diseases" of this class; but attention has been called to the circumstance that a certain stage of pulmonary consumption stimulates the sexual instinct to a degree which can hardly be supposed to benefit the exhausted state of the organism. The study of that indubitable fact offers a curious problem, but also a solution which considerably modifies the apparent paradox. The truth seems to be, that the tendency alluded to manifests itself only in a far advanced and practically hopeless stage of the disease, when Nature sacrifices the interests of the individual to those of the species. Moths, impaled in the collector's show-case, often pay an interest on the debt of Nature by a deposit of numerous eggs. Many plants ripen their fruit just before the end of the season. At the brink of Styx doomed men are apt to renounce individual cares and become eloquent for the benefit of posterity. It is Nature's law of reversion. It is also true that far-gone consumptives are very apt to indulge in exuberant hopes, belied by an event which they can hardly have helped to postpone.

But it is equally certain that, in a far larger number of diseases, instinct is the safest guide to recovery. The overloaded stomach rejects food; the exhausted system at last accepts no compensation but sleep. Wounded animals crouch motionless in their hiding-places; instinct informs them that rest increases the chances of recovery. The unrest of asthma-patients intimates the surest remedy—change of air and outdoor exercise. Fever-patients pant for refrigeration. Dyspepsia can be avoided by heeding the premonitory symptoms—the want of appetite that accompanies the first stage of chronic indigestion. In the incipient stages of scurvy, and many enteric disorders, the organism demands a change of diet as urgently as the perspiring skin clamors for a change of temperature. But when has that instinct ever clamored for drugs? If suppuration fails to dislodge a thorn, the skin of the inflamed parts becomes tenuous, and at last prurient, and not only tolerates but invites excision. We see, then, that instinct can adapt itself to abnormal circumstances, and the question recurs: In what state of distress does our stomach cease to protest against the compounds of the drug-monger? Or, shall we believe that our protective instincts, at the most critical moments, become false to their mission, and urgently warn us against the means of salvation? Yet, against ninety-nine of a hundred remedial drugs they protest with a persistence which can be overcome only by such juggles as lozenges and sugar-coated pills. That protest is a cliff which will ultimately wreck all the arguments of the castor-oil school. Home-sickness, if curable only by a counter-poison, inspires its victims to seek relief in friendship

(attachment transferred to less inaccessible objects), and sometimes in religious fervor—yearning for a home which even an impecunious traveler may hope to reach. Pliny marvels "how greatly disappointed love inspires to deeds heroic"; yet heroism, in the ancient active sense, self-devotion to hard work and rough-and-tumble campaigns, is, in truth, the best cure for the ailments of sentimental sorrow. The mountain-mania of worn-out brain-workers, their passionate longing for the occupations of their nature-abiding ancestors—hunting, camping, and horticulture—are inspired by the instinctive desire to re-establish the structure of their organism on the basis of its original foundations, and recover, as an uprooted tree might revive in the mold of its native soil.

The purpose of such intuitions has rarely been fully recognized, and there is no doubt that the most useful contribution to the medical literature of this century would be a popular treatise on the Revelations of Instinct. The didactic significance of those revelations may even be destined to become the basis of a special science. That science would help the votaries of reform to atone for the grievous heresies of the past. It would make the healing art an ally of Nature: it would preserve us from manifold social and educational errors, by guiding progress along the lines of natural ordination. A science of instinct would be the commentary of a gospel which, in the language of man, has almost ceased to be its own interpreter.

THE INCREASING CURSE OF EUROPEAN MILITANCY.*

By A. R. WALLACE.

SINCE the year 1870, but more especially since 1874, the general war expenditure of Europe has increased enormously. This is partly a consequence of the Franco-German War which so greatly enhanced the military power of united Germany and led other nations to aim at a corresponding increase in their forces, and in part to the enormously increased cost of iron-clad ships, monster guns, torpedoes, and all the scientific appliances of modern warfare.

Up to the year 1875 our own army and navy had increased but little for many years, the total expenditure in 1874 being £24,664,000, which was somewhat less than that of 1864. But since the former date our outlay on the two services has risen greatly, and now amounts to £28,964,000, an increase of more than four millions. The number of men has increased from 189,000 in 1874 to 197,000 in 1884, exclusive of the Indian army.

* Chapter V of "Bad Times," by Alfred Russel Wallace, LL. D. Macmillan & Co., 1885.

In most of the great states of Europe the increase both of men and of war expenditure has been far greater than ours. Austria up to 1874 spent less than seven millions on her army; she now spends £13,433,000, with an increase of about fifteen thousand men. France has increased her forces by fifty thousand men in the last ten years; while her military and naval expenditure has nearly doubled since the war, and now reaches the enormous sum of £35,500,000. Germany during the same period has raised her war expenditure by more than three millions, the present amount being £20,050,000. Italy has doubled her war expenses since 1873. In that year they were a little over nine millions, now they are £18,900,000. Russia has followed the same course, having increased her war expenditure from less than twenty millions in 1870 to £33,000,000 in 1884.

The loss involved in these huge armaments is of three distinct kinds: 1, by the number of men, mostly in the prime of life and of the very best physique, who are kept idle or unproductively employed; 2, by the burden of increased taxation which the rest of the community have to bear; and, 3, by the actual destruction of life and property in war, which, wherever it occurs, inevitably diminishes for a time the productive and purchasing powers of that country. Let us endeavor to form some conception of the amount of loss due to each of these causes.

From information given in successive issues of the "Statesman's Year-Book," it appears that, since 1870, the armies and navies of Europe have been increased by about 630,000 men on the peace establishments. This number of men, therefore, has been wholly withdrawn from productive labor; but during periods of war a much larger number is thus withdrawn, and the country is, to that extent, still further impoverished. But the total number thus withdrawn, though very large—the standing armies and navies of Europe being estimated at 3,683,706 men—represents only a portion, and perhaps even a small portion, of the mischief done, since the numbers employed in the equipment of this force and in the production of the vast and complex war-material now used are, not improbably, very much greater, and these are all equally lost for productive purposes. If we think of the hundreds of huge iron-clad ships which have recently been built, and try to form a conception of the number of men employed upon them directly and indirectly—from those who dug out the iron-ore, and the coal used to smelt the ore, to those who construct the huge and beautifully finished marine engines—from the men who felled the trees in Canadian and Indian forests to the skilled workmen who design and frame and finish with elaborate care the whole of the internal fittings—we shall be convinced that to build one of these monster vessels requires from first to last a small army of men, all of whose labor, so far as any benefit to mankind is concerned, might as well have been employed in pumping water out of the sea and allowing it to flow back

again. Then consider the equipment, clothes, arms, and ammunition of all these great European armies; the manufactories of powder and explosives, the monster guns and projectiles, the rockets and torpedoes, the horses and horse accoutrements, and all the innumerable variety of stores that are required to supply a modern army in the field—and then follow back every one of these things to the raw material brought from various parts of the world, and to the numerous processes of manufacture through which it has to pass—and further consider the amount of purely intellectual power required, the origination and improvement and detailed designs for the rifles and cannons, the projectiles and explosives, the pontoons, the fortifications, the torpedo-boats, and the iron-clads—and we shall probably think it not an extravagant estimate that for every ten thousand men in a modern army and navy at least another ten thousand are wholly employed in making the necessary equipment and war-material, the labor of the whole twenty thousand being utterly wasted, inasmuch as all that they produce is consumed, not merely unproductively and uselessly, but destructively. We may fairly estimate, then, that the military preparedness of modern Europe involves a total loss to the community of the labor of about SEVEN MILLION men, and a corresponding amount of animal and mechanical power and of labor-saving machinery. If, now, we consider that the weight of guns, the thickness of armor-plating, the size and engine-power of ships, and the complex requirements of an army in the field, have all been rapidly increasing during the last ten or fifteen years, we may fairly estimate that one fourth or one fifth of this number of men have been abstracted from the productive workers of Europe during the last ten years, the period over which the commercial depression has extended.

Let us next consider the heavy burden of taxation upon all the chief European peoples, the increase of which during recent years has been almost wholly caused by increased military expenditure and the interest on debts incurred for wars or preparations for war, for fortifications, or for military railways. This increase may be best estimated by comparing the expenditure of 1870, the year before the Franco-German War, with that of 1884. During this period of fourteen years our own expenditure has increased from £75,000,000 to £87,000,000; that of Austria from £55,000,000 to £94,000,000; that of France from £85,000,000 to £142,500,000; that of Germany from £54,000,000 to £112,500,000; that of Italy from £40,000,000 to £61,500,000; and that of Russia from £66,000,000 to £114,500,000. Altogether the expenditure of the six great powers of Europe has increased from £345,000,000 to £612,000,000, an additional burden of £266,500,000 a year. The population of these six states is now a little over 269,000,000, so that they have to bear, on the average, an addition of taxation amounting to nearly a pound a head, or about five pounds for each family, a most oppressive amount when we consider the ex-

treme poverty of the masses in all these states, and that even before this period of inflated war expenditure they had already to support a heavy and often an almost unbearable load of taxation. We must, therefore, admit that this great addition to their fiscal burdens in the last fourteen years must have seriously diminished the purchasing power of more than two hundred millions of people, and this alone is calculated to produce, and must actually produce, a depression of trade in all the countries which supply their wants, and therefore in none more seriously than in our own.

There remains yet to be considered the injury done by the actual destruction of life and property which occurs whenever this elaborate and costly war-machinery is put to its destined use. Owing to the wide extent and endless ramifications of modern commerce, wherever life and property are destroyed by war all nations with an extensive foreign trade must feel some of the consequences. When villages and towns are burned or bombarded, crops devastated, and domestic animals taken by invading armies, troops quartered on the inhabitants and forced contributions made, the result must be the impoverishment of the population for several years. For a long time they have a severe struggle even to exist. Their houses have to be rebuilt, their lands to be again cultivated, seed and domestic animals to be procured, fresh capital to be accumulated; and till all this is done they have no means of purchasing foreign goods or of indulging in anything beyond the barest necessaries of life. And, when the war is long and destructive, there is, in addition, the loss of human life, not merely by slaughter in battle, but by the distress and exposure, the disease and famine which are the inevitable consequences of war, a loss often to be counted, not merely by thousands and tens of thousands, but even by millions. And all these lost lives are, from our present point of view, lost customers, and thus still further increase the sum total of injury to commerce which war produces.

Now, during the last twenty years there have been a continued series of wars which have all, more or less, tended to produce these injurious effects. Beginning with the New Zealand war in 1865, we have in succession the Abyssinian war of 1867, the great Franco-German war of 1871–'72, the Ashantee war in 1875, the terrible Russo-Turkish war of 1878, the Transvaal, Zooloo, and other South African wars of 1879–'80, the Afghan war of 1881, the Egyptian war of 1883, and the Soudan war perhaps not yet concluded. Who can calculate the amount of life and property destroyed, and the consequent misery and impoverishment of large populations during these twenty years? Traders have, unfortunately, often considered war to be advantageous to them, on account of the rapid and reckless expenditure of public money on war-materials and stores, and the opportunity of making large profits by war-contracts. But this is a very partial effect and limited to but few departments of trade, while the depressing effect of

war, in the increased taxation it always involves and in the impoverishment of our customers which it always produces, is certain, widespread, and often enduring. The recent wars in Egypt and the Soudan, whatever other results they may have, will assuredly have the effect of tending still further to prolong and intensify our commercial depression.

If our manufacturers and merchants as a body would consider this question in all its bearings they would surely arrive at the conclusion that all war, wherever or by whomsoever waged, is bad for trade, since it impoverishes alike the winner and the loser, the invader and the invaded, while it inevitably destroys a number of actual or possible customers. The moral arguments against war would doubtless be more generally effective if it were clearly seen that, always and everywhere, its direct and necessary effect is to produce more or less of depression of trade.

But if war injures the capitalist, the manufacturer, and the trader, still more does it injure the worker, and on this point I can not do better than quote the forcible words of Mr. Mongredien.* After describing the various destructive agencies and methods of war, he says: "As wealth dwindles somebody must suffer, and the suffering mainly falls on the poor and weak. The capitalist is mulcted of part of his wealth, but he can wait. The labor-seller is mulcted of the necessaries of life, and he and his dear ones can not wait. The less there is to produce the less there is to distribute. Need we say which class it is that will run short? It is on you, labor-sellers of the world, that the burden chiefly falls. It is you who are the slayers and the slain. You form the rank and file who deal the blows and on whom the blows are dealt. To your chiefs belong the honor and the rewards. As for you, you are under contract to suffer and to cause suffering; to inflict and to endure death; to destroy instead of creating wealth; and to use every effort to suppress the fund out of which labor is paid. The war-system, pernicious to every class, is a special curse to yours. Are you content to view it as a necessity? In this our protest against it, we look for your special assistance by thought, word, and pen. Public opinion is made up of assenting units." Since these words were written the working-men of England have obtained the means not only of verbally protesting, but of actually deciding against war, if it so pleases them. If they will vote for no representatives but such as will pledge themselves to oppose all but strictly defensive wars, and never to begin a war until we are actually attacked, then war will rarely occur, war expenditure will be reduced, and, so soon as other nations follow our example and that of the United States, one of the chief causes of depression of trade will cease to exist.

* "Wealth Creation," by Augustus Mongrieden, p. 115.

MEDICAL PRACTICE IN DAMARALAND.

By C. G. BÜTTNER.

THE missionary in Damaraland has also to be a physician. The stations in that country being cut off from regular intercourse with European civilization, the missionary societies have been obliged to give their agents a medical education, in order, if for no other purpose, that they may be able to doctor themselves and their families. From my own station of Otimbingue, which is well situated as compared with some of the others, I would have had to go at least a month's journey to find a regularly graduated physician. Of course, the natives are glad to avail themselves of the benefit of what medical skill we may have, the more especially as they have learned that we will never intentionally do them any harm, while they are always suspicious of their own doctors and sorcerers. Hardly a day passed during my residence in the country that I was not called upon by some sick person; so that I am able to speak from the results of a seven years' busy practice. As I could converse with the natives with perfect freedom in their own language, I had frequent opportunities to consult with their professionals, and was able to learn more of their notions than usually falls to the lot of the ordinary explorer; so that, though not a physician by profession, I believe I can make some interesting contributions to medical lore.

One of the most curious results of my observations is that the climate of Damaraland possesses what we might call an antiseptic character for several months of every year. The quality is an attendant of the long annual drought. Every living thing suffers during that period from the excessive heat, and much comfort is impossible, even in the shade, while, in places exposed to the warm winds, the thermometer has risen to 129°; and the sand, unmoistened for six months, becomes so hot that I have seen eggs hardened in it. This arid heat is opposed to the propagation of ferment, for it dries up everything that is exposed to the wind before it has time to sour. No manifestations of tuberculosis are known. Wounds of every kind heal remarkably quickly and well, without enough suppuration taking place to make the bandages stick. The manner in which large, neglected wounds heal of themselves would form an interesting study for a professional surgeon. I observed a case of a Herero whose right lower arm had been shattered in battle by a musket-ball. The healing process had worked itself out in such a way that the whole lower arm with all its muscles had become withered and useless, while the upper-arm bone was whole and covered at its lower end only with the brown skin. All the muscles and ligaments of the elbow-joint had vanished, while the shoulder-muscles remained, so that the unpleasant spectacle was pre-

sented of the man appearing to gesticulate with his bones. A woman lived at our station whose feet had been barbarously cut off in some war several years before, so that her captors might more easily get off the iron ornament which the Herero women wear on their ankles. Athough the woman had to lie helpless for a long time, her wounds eventually healed up, and now she has been hopping around on her knees for thirty years.

We soon remarked, however, when the rains fell, a *genius epidemicus* coming over the country and demanding offerings. We could also see how those of the natives who lived on the ridges were much less troubled by illness than those whose houses were situated on the moister alluvial ground and in the river-bottoms. Those who have once had fever are more readily exposed to attack than those who have never been ill. My wife, who appeared to have wholly recovered from a recent illness, only required a stay of ten minutes in a river-bottom, where I and several other persons received no injury, to be put in bed for months. The influence of malaria is manifested in many persons in other ways than by fever-and-ague. Thus, I never had that disease; but, when others of the family had fever, I had rheumatic pains in my joints, and I knew of other persons who were similarly affected. Occasionally a severe and almost universal influenza would prevail instead of the fever; and, while few died from it, it was very painful, and sometimes laid entire households low, so that no one was left to attend to the daily duties.

One of the most prevalent diseases is a running inflammation of the eyes, which few natives escape suffering from one or more times during their lives. Europeans also are usually attacked by it, and it was a great wonder to the natives that I and my family escaped it. We avoided it by the observance of the most scrupulous cleanliness and the use of prophylactics.

Venereal disorders are quite widely spread, but the Hereros have no name of their own for them, and call them the "Hottentot disease."

A peculiar skin-disease, called *otiyndimba*, causes much inconvenience. It is connected with the hot weather, and is characterized by little sores that appear upon different parts of the body, lasting for two or three weeks, to be succeeded by others till the cold weather. They develop pus, in quantity which appears to be very scanty in proportion to the pain they cause, and leave no scar. The only disturbance they produce in the general system appears to be to make the sufferer very uncomfortable.

Two cases of snake-bites were brought to me, one of which was without consequences, while the other only resulted in a trifling sore. Yet cattle are frequently killed by snakes. I had several cases of men who had been spit in the eyes by the spitting-snake, or *ongoroka*. Some persons regard this serpent as a myth; but I have conversed,

not only with natives, but also with trustworthy Europeans, who have seen it spit. The attack produces a running inflammation in the eyes, which lasts for about a fortnight.

The various behavior of the natives toward surgical and internal disorders is curious to the European. No one can be more indifferent than they are to external injuries and the pains they occasion. Except in the rarest cases, they never utter a sound or move a limb, whatever may be done to them. A thoroughgoing surgeon could not want better subjects; and only when the question is directly asked them will they admit that they suffer any pain. An illustration of this power of endurance is given by the poorer mountain Damaras, whose clothing, for summer and winter, is reduced to a mere loin-cloth. Their only way of warming themselves in cold weather is to hover over the fire as closely as possible. They thereby become blistered nearly from head to foot, and acquire a rather mottled appearance; yet they never seem to mind the smart of the burns. But let them suffer from any slight internal disorder, if it be no more than a common cold, no one can touch them, and it is very hard to make them submit to a medical examination. It was common in our school when one asked a person suffering from such a disorder, "Where do you suffer the most pain?" for him to return the answer, "In my arms, neck, head, back, stomach, all over my body." These imaginary sick gave us a great deal of trouble, and it became necessary to keep them as much out of the way as possible. I found an effectual means to accomplish this, and one that was characteristic of the people. I ordered calf-soup for the sick man. To kill one of their calves was more than the Hereros were willing to do just to make a sick man well; and no one to whom I made this prescription ever came to me a second time.

Massage plays an important part in native therapeutics, and is applied upon the whole of the lower part of the body and the bowels. I can not deny that this operation is quite thoroughly and in a manner scientifically performed. It is a circumstance favorable to this process that the skin over the abdomens of the natives is stretched and flabby on account of their custom—which arises from their necessities—of overeating at times, and at other times having to endure long hunger. The operator, first with a slow, light, but continuous movement of his oiled finger-tip draws the bowels clear over to one side till he can plainly feel the inner part of the hip-bone with its muscles and vessels on the other side; then the bowels are slowly pushed back, with a movement so executed that every knot and every induration is rubbed as thoroughly as possible between the fingers. A number of the unpleasant symptoms that may arise from costiveness, uterine disorders, or the troubles of pregnancy, are removed by this operation, and it can not be denied that the effect of the kneading on the circulation is beneficial. The whole process lasts from an hour to an hour and a half, and in serious cases is repeated every two or three days.

The men who perform massage have by repeated practice acquired a fair knowledge of the normal condition of the abdomen, and of the more usual irregularities that take place there; and they have also, by practice in cutting up slaughtered animals, gained some knowledge of the anatomical relations of the parts. I have satisfied myself, by close observation of the procedure, that every part can be so fully separated from the others as to permit the whole to be plainly felt by the finger.

The skill attained in this art is particularly serviceable in midwifery cases, and makes up in a great measure for the lack of instruments. By it faults in the position of the fœtus are soon discovered, and much skill is displayed in remedying them. Even the white women are not afraid to call in the native midwives; and they can really be recommended without peril. As a rule they are women of the higher social ranks. The art of massage is handed down from mother to daughter, or to other relatives of the younger generation. Occasionally men practice at it.

Chest-diseases and pains in the extremities are treated by cupping and the moxa. Cupping is done with a horn. The skin having been scratched with a knife, the larger end of the horn, which has an opening at the point, is placed over the wound, and the operator sucks out the air and as much blood as he can, making of himself a kind of an artificial leech.

Moxas are preferred for diseases of the lungs and liver, and are applied in the simplest imaginable manner, by burning the end of a stick and putting the glowing coal upon the skin. Some ten or fifteen points are thus burned in succession, the scars of which afterward look like a kind of tattooing. When I first saw these scars on the breasts and backs of the Hereros, I thought they had been made for decoration, but was soon set right in the matter.

For internal remedies the people have a considerable number of simples. Every one knows of a few plants that are good as laxatives, emetics, sudorifics, or quietives. Among the heathen natives, supernatural help appears to be regarded as more important, and to be more approved. It is invoked, I observed, in two forms: One kind seems to be a traditional survival of the old patriarchal sacrifice; and the other embraces a kind of combination of secret knowledge with jugglery. A very obvious distinction is made between the two kinds of invocation, in the fact that some honorable member of the family is chosen to officiate in the former, while the latter is left to some wretched charlatan, or juggler, who sometimes has to suffer death as a penalty for his practice. In the former kind of invocation a beast is always slain, with whose meat and fat certain ceremonies are performed and formulas uttered over the patient, in a way that has been handed down by tradition.

One of the simpler features in the practice of the juggler-doctors

consists in the practitioner sucking at the afflicted part of the patient till he brings out the thing that has produced the sickness. So long as these things are beans, pumpkin-seeds, and the like—and these are what the doctor generally finds—there is nothing about the matter that passes our comprehension. But when I saw one of these performers, entirely naked except for a little skin-apron, who was closely watched by many curious persons, at last draw out a living snake, a foot and a half long, I was somewhat astonished. It was a real snake, for the by-standers hastened to kill it. If the sick man failed to get well after this kind of procedure, the burning coal was applied to him. Hottentot quacks generally give the patient to drink of a kind of tea which they compound from plants known to them, and which should cause him to vomit. For the cure to succeed they must find the object by which the man was bewitched and made sick, in the vomited matter. These objects are things which can not usually be found in the stomach nor come out of it. Thus my friends were shown, among the things that had been in this way taken from patients, large pins with glass heads, neatly tied together, crosswise, with a red thread, a piece of wood with several twigs forking from it, and almost as large as the hand, and other things equally curious. So far as I could learn, this process is usually applied to a St. Vitus's dance, which is supposed to be caused by enchantment.

I close with the relation of an incident in which I was made to play the part of the magic doctor, because it exhibits one of the characteristics of the people. A Hottentot came to me with a story of his nephew being bewitched, and said that he had sought me out after several other white men had declined to help him, because they knew nothing about witchcraft. His nephew, he told me, had been quite well till he had been bewitched by a rival in a love-affair, and nothing could now be done with him, for his convulsions and running around. As this condition had come about all of a sudden, the suggestion of some external cause for it was obvious, and I was satisfied that it was a case of poisoning. For the quacks are adepts in the management of snake and plant-poisons, and produce all their enchantments, when they amount to anything, by some means of the kind. I was glad to have the opportunity of dealing with one of these cases by a remedy of my own. I gave the man a bottle of camphor, with directions for using it, and told him to come back and report the result in a fortnight. He came three weeks afterward, with the empty bottle, and told me joyfully that the sick man was well; he had vomited up the lion's hairs in which the enchantment was lodged!—*Translated for the Popular Science Monthly from Das Ausland.*

THE PROBLEM OF PHOTOGRAPHY IN COLOR.

By OGDEN N. ROOD,
PROFESSOR OF PHYSICS IN COLUMBIA COLLEGE.

MY attention was first called to this subject in 1853. At that time I was an assistant in the "Yale Analytical Laboratory," which afterward developed into the present Sheffield School. The interest of the Professor of Chemistry, John Porter, was excited by some articles on this subject which had recently appeared in France, and he was desirous of making experiments to test an idea that had occurred to himself. The sensitive surface was to be prepared while actually under the influence of colored light, so that from the start the colored rays should be able to act on it and influence the molecular condition of the newly formed combinations. A prismatic spectrum was to be employed, and it was hoped that the red rays would persuade the newly born silver salts to reflect red light and only red light, while the same salt, when generated under the influence of the green rays, by the aid of this early education was to be made capable hereafter of reflecting green light, but incapable of reflecting red, yellow, or blue light. Expressed in the language of the undulatory theory of light, the idea would be about as follows: expose molecules in act of formation to the long waves of red light, and ever after they will be capable of reflecting mainly the long waves of red light; all other kinds they will absorb and convert into heat.

This task having been assigned to me, I entered on it with zeal, and arranged a dark room; the solar spectrum was made to fall nicely on the table, and many of the processes known at that time were in succession tested. The photographs of the spectrum thus obtained were not at all uniform in color; sometimes they would be delicately shaded from a dull-red gray to a blue or violet-gray and often they presented minor changes of color variously disposed. Favorable indications were followed up as they presented themselves; but after a time I became convinced that the play of color in the photographs was solely due to the greater or less energetic action of the light upon the sensitive substance, and that exactly the same results could be obtained by using white light, more or less intense. When the work was finished, I presented my written report with the photographs, and the professor, after studying it, came to the same conclusion. The "nascent" idea was not feasible.

And yet photographs in color of colored objects have been obtained. Upon one occasion, about twenty-five years ago, I obtained a very fine one. The subject was a large elm-tree and a red farmhouse, these two objects filling up almost the whole plate. The ordinary wet-collodion process was employed; the negative, after being

removed from the hypo, was washed and dried as usual; but, when I examined it by reflected light, it turned out that the green tree was colored dark green just as nicely as if it had been a camera image, and the red house was not a bit behindhand in truth and delicacy of hue. A photograph in colors, sure enough! But an examination with a lens, and a little turning and twisting of the plate, caused the illusion to vanish: the colors were those of "thin plates," soap-bubble colors, caused by the interference of light. Wet collodion often shows them in patches when it is somewhat rotten, and this sample was very rotten. The interference effect had nothing to do with the *color* of the light, but was controlled by its intensity. Once I had a chance to examine some photographs in color of gayly dressed dolls made by Niepce de Saint-Victor, and it seemed to me that the pale colors they presented were produced by a species of interference, acting by means of the presence of *more* or *less* finely divided particles. The details of my examination I do not recollect, but merely the conclusion that the appearances presented were due to causes analogous to those that were effective in the case of my glass negative. Photographs in color, such as they are, can be obtained with sufficient patience; but, in order to give this fact the slightest value, it is necessary to prove that a corresponding amount of patience would not be rewarded by the production of colored photographs of objects which were gray, light gray, dark gray, etc. When we think we have made a discovery, our first duty is to destroy it mercilessly if possible, and the reproduction of the same effects with white or gray objects is the proper mode of administering justice in this case. It is barely possible that some one may ask why a process that renders the colors correctly is a failure merely because corresponding colors can be obtained when the natural objects are tinted gray. The question answers itself; white and gray objects will be colored in the photograph, and, worse than that, the same color in the natural object will vary in the photograph with its brightness or luminosity.

Let us now examine this subject from a theoretical point of view, and ask ourselves why we should hope that photographs in color could ever be produced. We see the rich red rays of the spectrum falling on the plate, and we imagine that a substance which is sensitive to light will somehow be acted on by them, and arrange itself so that ever afterward it will better be able to reflect red light than any other kind of light. Why? Why should a substance that has been acted on by long waves be better able to reflect long waves than those that are shorter? Why should a sea-beach that has been acted on by long waves be on that account better able to reflect and redirect to the ocean long waves rather than mere ripples? The waves of light produce in sensitive substances chemical changes; new compounds are formed; why should the long waves of red light produce compounds that are especially capable of reflecting long waves, or red light?

When we undertake to make a photograph in color, in effect we ask one and the same chemical substance to reflect for us long, medium, or short waves, red, green, or blue light, according as it has been acted on by waves of greater or lesser length. The demand seems to me preposterous.

The hope for photography in color lies in a different and less independent direction. By the use of suitably colored plates of glass placed before the lens of the photographic camera, it is possible to obtain ordinary negatives of the red, yellow, and blue constituents of a brightly colored surface—a carpet, for example. These can be made to yield red, yellow, and blue positives by the aid of the photo-lithographic process ; and when these three positive impressions are superimposed on the same sheet of paper, a more or less successful reproduction of the colored object is obtained. The selection of the three transparent pigments used in printing is necessarily left to the taste and judgment of the operator, or I should say artist, as without considerable artistic knowledge the results are not likely to be valuable. It will be seen, then, that in this process photography is really made to act as an aid to chromo-lithography, and the results are really chromo-lithographs, the work being mainly performed by the camera and colored glasses. I do not see why it should not be possible in this way to reproduce more or less successful colored pictures of brightly tinted objects.

When we come to landscape the problem is more difficult, for a large part of its color consists of delicately tinted grays, the handling of which would be, to say the least, very troublesome, and would require far more than the superposition of the three layers of pigment just mentioned. For progress in this direction it would be necessary that the experimenter should, at the same time, be a skillful photographer, a good chromo-lithographer, and a landscape-painter. The results obtained would not be exact representations of natural scenery, but rather sketches in which the artistic taste presided over, modified, and massed together natural tints. They would be none the worse for that. Of course, there would still remain the difficulties connected with an artistic disposition of light and shade, and the still more insuperable ones of composition ; for the disposition of objects in a landscape is rarely just what we want, or even what we are willing to tolerate. On the other hand, there are many simpler objects where this process * would probably succeed very well, such as colored designs of all kinds of decorated objects, and all those cases where the coloring is simple and not too evanescent.—*Photographic Bulletin.*

* Due originally to C. Cross and Ducos du Hauron, and improved by Albert, of Munich, and Bierstadt, of New York.

WOMEN IN ASTRONOMY.

By E. LAGRANGE.

THERE have been women famous in all the departments of science and art, and many have shown in astronomical studies talents not usually made manifest in their sex. To begin with ancient times, several women whose names have come down to posterity made themselves famous in the centuries before the fall of the Western Roman Empire. Among them, the principal one who derived her title to glory from the study of the sciences was Hypatia, daughter of Theon, of the school of Alexandria, who is nevertheless better known by her philosophical opinions than by her scientific labors. She lectured for many years at Alexandria, before numerous and intelligent audiences, on the Neoplatonic doctrines; but she is also known as the author of an astronomical table which has not come down to us. Wolf relates, in his "History of Astronomy," that she studied mathematics and astronomy with such success that she was given a professorial chair, whence she explained the works of Apollonius and Diophantus.

Skipping the ages of darkness and the beginning of the modern epoch, we find our attention fixed in the latter part of the seventeenth century upon the name of the family of Kirch—a name important in many respects. Marie Marguerite Kirch was born at Panitzch, near Leipsic, on the 25th of February, 1670. Her maiden name was Winckelmann, but she married the Berlin astronomer Godefroid Kirch, and became also his scientific companion. She assisted him in his calculations and observations, and in 1702 discovered a comet. Even after the death of her husband in 1710 she did not cease to devote herself entirely to astronomical science; and we have a considerable book which she wrote in 1712, in anticipation of the conjunction of Jupiter and Saturn that was to take place in 1713. The conjunctions of the planets now only excite curiosity, and are of no particular interest to astronomers. But the case was different in the times when astronomy was mixed up with astrology, and a very capricious, occult influence over earthly fates was attributed to such especial positions of the stars. With the progress of theoretical astronomy, which showed that these conjunctions were regular events, subject to periodic laws, the ideas on this subject were modified, and the writers upon the phenomena took the pains to notify the public, by the titles of their works, that they had nothing in common with the astrologers. Marguerite Kirch's book consisted wholly of astronomical calculations—to the honor, says Bach, of the woman and her age.

The daughters of Madame Kirch continued to occupy themselves

with astronomy after the death of their mother, and made the calculations, for the Academy of Sciences of Berlin, of the "Ephemeris" and the "Almanac" which were sources of revenue to that learned body. In the same period a number of French and Italian astronomers had female collaborators in their own families. Celsius, the celebrated professor at Upsala, and a pupil of Kirch the son, was entertained, while passing through Paris to Bologna, by De l'Isle, whose sister was devoting herself to astronomy. Reaching Italy, he found likewise that his new master, Manfredi, had two learned sisters, engaged, like their brother, in the study of the stars. This caused Celsius to say, in a letter to Kirch: "I begin to believe that it is fated for all the astronomers whom I have had the honor of becoming acquainted with during my journey to have learned sisters; I have a sister, too, but not a very learned lady. To keep up the coincidence, we must make an astronomer of her."

Other women, whose names are less well known, wrote on astronomy during the seventeenth century. We may cite Maria Cunitz, daughter of a Silesian doctor, who published astronomical tables in 1650; Jeanne Dumé, who in 1650 wrote a book defending the Copernican system against "scientific" attacks upon it. Of more modern date was Madame Gabrielle Emilie de Breteuil, Marquise du Châtelet, who was for fifteen years the constant friend of Voltaire, and in her retreat at Cirey devoted her whole life to the sciences. She it was who first made known to France, then devoted to scientific Cartesianism and the doctrine of elementary vortices, the masterly work of Newton. This was a title to glory which might have made the fortune of more than one scientific man, and it fell upon a woman. Mademoiselle de Breteuil had received a very careful education, but her natural taste for study and serious occupations did not prevent her from shining brilliantly in the society of the courts of the Regency for some years after her marriage with M. du Châtelet. One of the best evidences of her genius that we have is in the bearing toward her of Voltaire, who had no respect for any but mental gifts. He had returned from Great Britain full of enthusiasm for English science and philosophy, and occupied with the dream of making Newton known to his countrymen and dethroning Descartes at the Academy. It may appear singular that he selected Madame du Châtelet for this work; but the choice was not extraordinary after all. She had already made some progress in mathematical studies under the direction of Maupertuis and Clairaut, and Voltaire was looking for the assistance he needed to some one outside of the official scientific circle. The translation of Newton's "Principia" would be the best means of making known in France the great English geometrician and the admirable simplicity which his theory of attraction lent to the study of the movements of the stars. This work Madame du Châtelet did well. But she did more than make a simple translation. The algebraic com-

mentary which follows the translation is in large part the work of this lady, although it was composed under the direction of Clairaut and revised by him. "We have witnessed two prodigies," said Voltaire in his historical introduction to the "Principia"—"one that Newton should have composed this work, and the other that a woman should have translated and elucidated it." Leaving out the exaggeration natural in such a statement, there is still a great deal of truth in it. More than ordinary mathematical knowledge was necessary even to make known a work like Newton's immortal treatise, and still more to add explanatory comments to it. This, however, was not Madame du Châtelet's first scientific work, for she had previously written for her son "The Institutions of Physics," a book imbued with the Leibnitzian philosophy.

As may readily be imagined, Madame du Châtelet was likely to find more enemies than aids among the women of the light and frivolous society of her day. Fortunately, she was indifferent to criticism, else she would have suffered the pain of a hundred deaths.

The most distinguished of all woman-astronomers was Caroline Herschel, the story of whose life, already fully told in this journal (see "Popular Science Monthly," April and May, 1876), is familiar to our readers, and needs not to be repeated.

Madame Rümker, wife of the former director of the observatory of Hamburg, and his constant aid, discovered a comet on the 11th of October, 1847—the first comet discovered by a woman since Caroline Herschel had announced the last of her eight, fifty-two years before. [M. Lagrange has curiously omitted to mention the American woman-astronomer, Maria Mitchell, who is entitled to the place among discovers of comets which he here gives to Madame Rümker. She discovered a telescopic comet on the 1st day of October, 1847—ten days before Madame Rümker's discovery—in recognition of which she was given a gold medal by the King of Denmark. She has also devoted much attention to the examination of nebulæ, and has been employed in observations connected with the Coast Survey and in compiling the "Nautical Almanac." Her work has hardly been inferior to that of any of the women mentioned by M. Lagrange.—Ed. Popular Science Monthly.]

Another lady, who left very distinct traces of her work in astronomical science, was Madame Scarpellini, whom Italy claims as one of the children that have done her the most honor, and to whose memory a statue has recently been erected.

Catherine Scarpellini was born at Foligno on the 29th of October, 1808, and was a niece of the astronomer Feliciano Scarpellini, founder of the Capitoline Observatory, restorer of the Academia dei Lynceii, and professor in the two universities of Rome. Her attention was directed to scientific studies by her early training, with which her tastes fully agreed. Among her titles to fame we may recount that

she organized the Meteorologico-ozonometric Station of the Capitol, and edited its monthly bulletin; she was one of the most active collaborators in the "Scientific Correspondence" of Rome; and, like Caroline Herschel, Madame Rümker, and Miss Mitchell, she discovered a comet on the night of the 1st of April, 1854. At a time when the subject of shooting-stars was under lively discussion she prepared the first catalogue of the meteors observed in Italy, and was the sole observer at Rome of the great shower of 1866. She also left valuable studies on the probable influence of the moon on earthquakes—a work which brought her distinctions from the Society of Naturalists of Moscow, the Geological Institute of Vienna, and other scientific bodies. Many learned societies made her an honorary member, and the Italian Government, in 1872, decreed to her a gold medal for her statistical labors. With all this she was a good mother and a true woman.

We mention a few more names: Madame Hortense Lepante, wife of the horologist of the same name, who calculated a comet with Lalande; Miss Ashley, of our own time, who has so intelligently studied the surface of the moon, and whose numerous labors are registered in the "Selenographical Journal"; and Miss Pogson, who is directing an observatory at Madras. Several young women are employed as calculators at the Observatory of Harvard College, in Cambridge, Massachusetts.

I can not close my article without giving grateful testimony to those women who, without having contributed directly to the advancement of astronomy, have sustained their husbands or brothers during their work with incessant devotion. This is a beautiful part reserved for the astronomer's wife or sister, and many women have known how to fulfill it with honor.

We recall with an emotion of gratitude the name of Mrs. Asaph Hall, whose persevering energy supported her husband when, despairing of success, he was on the point of abandoning the search for the satellites of Mars. With her encouragement, after long and painful watches, Mr. Hall returned once again to his investigations in a final effort, which was crowned with a most brilliant success. I must also, with all the friends of science, give a tribute of homage to Madame Janssen, who has exiled herself several times to the ends of the earth, and accepted the privations of the hardest kind of life, to follow her husband in his numerous astronomical voyages.

Honor, then, to all these ladies and fellow-workers, who are pleading or have pleaded more emphatically than the strongest speeches of philanthropists in favor of the claims of their sex. They have proved that when one will one can; and that proverb is perhaps the best conclusion that can be drawn from our story.—*Translated for the Popular Science Monthly from Ciel et Terre.*

SKETCH OF DR. W. B. CARPENTER.

THE long and busy scientific life of Dr. Carpenter, the wide extent and multifarious character of his researches, in which he was always a leader and always advanced knowledge, the catholicity of his views, the active interest he exhibited in every concern of life, his lovable personal qualities, and the painful circumstances of his death, have all contributed to invest the history of his career with an unusual degree of interest.

His life, as he observed to a friend less than a month before his death, was one of hard work. He was for years actively engaged in the drudgery of teaching; he was always preparing and compiling valuable manuals; he was an energetic writer for, and editor of, periodical publications; and, we may add, he spent much time in the direct service of the public and of public institutions. A sketch of his life and work down to 1872 was given in the first volume of "The Popular Science Monthly." But he has held so high a place, and has done so much that is valuable since then, and as that biography is probably not now accessible to a great many of our readers, no apology need be offered for reviewing the principal features of Dr. Carpenter's career, and adding, with the account of his later work, such new information as is afforded by the reminiscences which are always brought out by the death of a man who has played an important part.

WILLIAM BENJAMIN CARPENTER was born in Exeter, England, October 29, 1813. His father, the Rev. Dr. Lant Carpenter, was an eminent Unitarian minister, and a writer on theological subjects, who removed to Bristol in 1817. Hence the son's earlier life became so identified with that city that some of his biographers have said that he was born there. The whole family are characterized by ability. Dr. Carpenter's sister, Miss Mary Carpenter, who died a few years ago, was an eminent philanthropist, whose work in relation to the treatment of prisoners, and to questions affecting the well-being of the women of India, entitle her, as Dr. Ray Lankester happily says, to be remembered by future generations with no less gratitude than her brother. His sons are men of mark in the Unitarian ministry, in literature, and in science.

He received his earlier instruction in the school established by his father at Bristol, studying the classics and the principles of physical science, with a preference of taste for the latter class of studies. He intended to become a civil engineer, but, no suitable opening appearing in that profession, he entered upon the study of medicine, in 1828, with Mr. J. B. Estlin, a brother-in-law of Dr. Pritchard, the ethnologist, in connection with which he attended the lectures at the Bristol Medical School. In the winter of 1832 he visited the West Indies in company with Dr. Estlin, who went on a voyage for his health, to re-

WILLIAM BENJAMIN CARPENTER, LL. D., F. R. S.,

President of the British Association for the Advancement of Science.

sume his studies on his return, at Bristol, then at University College, London, and finally in the University of Edinburgh, where he received the degree of M. D. in 1839. His graduating thesis, which gained for him a gold medal, was on "The Physiological Inferences to be deduced from the Structure of the Nervous System of Invertebrated Animals." It attracted considerable attention on account of some peculiar special views advanced in it, and it pointed out the direction which his future studies were destined to take. Previous to his graduation he had been appointed Lecturer on Medical Jurisprudence in the Bristol Medical School. He settled down to practice and married in Bristol; but, in 1844, feeling a distaste, according to Dr. Lankester, for the profession of medicine, he removed to London in order to devote himself entirely to a literary and scientific career. Here he was appointed Fullerian Professor of Physiology in the Royal Institution, and was made a Fellow of the Royal Society; in the next year he became a lecturer in the London Hospital; in 1847 a lecturer on geology in the British Museum, one of the examiners of the London University, and editor of the "British and Foreign Medico-Chirurgical Review"; in 1849, Professor of Medical Jurisprudence at University College; and in 1852, Principal of University Hall.

Dr. Carpenter began the researches with which his name is associated and the publication of results upon them while still quite young. Two books—Sir John Herschel's "Discourse on the Study of Natural Philosophy," and Lyell's "Principles of Geology"—exerted a great influence over his mind while he was a student, and served in a certain sense as models in the execution of the literary part of his work. Dr. Lankester remarks that from the first his work showed the tendency of his mind to seek for large generalizations and the development of philosophical principles. "He was a natural philosopher in the widest sense of the term—one who was equally familiar with the fundamental doctrines of physics and with the phenomena of the concrete sciences of astronomy, geology, and biology. It was his aim, by the use of the widest range of knowledge of the facts of nature, to arrive at a general conception of these phenomena as the outcome of uniform and all-pervading laws. His interest in the study of living things was not therefore primarily that of the artist and poet so much as that of the philosopher, and it is remarkable that this interest should have carried him, as it did, into minute and elaborate investigations of form and structure." Among his earliest contributions was a paper "On the Voluntary and Instinctive Actions of Living Beings." Before he was twenty-five years old he had published articles on "Vegetable Physiology" and "The Physiology of the Spinal Marrow," and a review of that part of Whewell's "History of the Inductive Sciences" which relates to physiology. His first important essay in the study of the nervous system, the special branch of the science to which he more closely devoted his attention, was a review of Noble's "Physiology of

the Brain," in which he exposed the unscientific character of the claims of phrenology. In this paper he also extended the idea of reflex nervous function to the centers of sensation and ideation, and enunciated the fundamental notions of "consensual" and of "ideo-motor" action. Curiously Mr. Carpenter's arguments converted the author of the book, Dr. Noble, who in a short time surrendered the principal hypotheses which he had endeavored to enforce in it.

His first systematic work, produced in 1839, was the "Comparative Physiology," or, to cite it by its full title, the "Principles of General and Comparative Physiology, intended as an Introduction to the Study of Human Physiology, and as a Guide to the Philosophical Pursuit of Natural History." This work, which has passed through many editions, and is even now, though out of print, hardly behind the times, is acknowledged to have been when it was first published the best arranged and most clearly written work on physiology in the English language. It was a pioneer and successful effort to deal with the phenomena of animal and vegetable life as parts of a single whole in the manner that is now almost universally done in treating of the science of biology. While residing at University Hall, from 1851 to 1859, he remodeled this work and divided it into two parts: the "Comparative Physiology," comprehending the general biological portion; and the "Human Physiology," consisting of the part relating to the special physiology of man and the higher animals. The "Human Physiology" embodied the most complete and thorough exposition of the subject that had yet been presented, and was particularly remarkable for the manner in which the physiology of the brain and nervous system was treated, and for the introduction of the theories of cerebral localization which have since been elaborated with increasing exactness and remarkable results. The part of the book relating to this branch of the subject, developed and matured by subsequent studies, was published separately in 1874 as the "Principles of Mental Physiology," a book which "Nature," in its review of it, characterized as marking the author as one of those philosophers "who refuse to treat the phenomena of mind as though they were in no way connected with the body through which they find their expression." Rejecting the method of treating mental phenomena as abstracted from their surroundings, Dr. Carpenter based his system on the construction and working of the nervous system. "But while shunning the metaphysical system," the reviewer in "Nature" continues, "he does not adopt the other extreme, the doctrine, we mean, of the thorough materialist, who regards all mental phenomena without exception as the outcome of previous physical causes which necessarily produce certain results. He steers a middle course, inasmuch as, while he advances the theory 'of the dependence of the automatic activity of the mind upon conditions which bring it within the nexus of physical causation,' he yet believes in 'an independent power controlling and directing that activity which we call will.'"

This doctrine of the independence of the will is regarded as one of the distinguishing characteristics of the philosophy of the treatise, running "through the entire work as the one grand exception among a series of physical sequences, interdependent, and standing to each other in the relation of cause and effect, of antecedent and sequent." Another important feature of the book is found in its discussions of the subjects of mesmerism, spirit-rapping, table-turning, and the like, in which the author's philosophical spirit is eminently displayed. He set himself soberly at work to find out what is true in these manifestations, and to verify the facts, and explain on rational grounds those which were susceptible of explanation, while "he did not hesitate to denounce those he thought were due to insincerity or fraud." He found the key to such of the phenomena as are real in what he called ideo-motor action, which he defined to be "the direct manifestations of ideational states, excited to a certain measure of intensity, or, in physiological language, reflex actions of the cerebrum." His observations on this branch of the subject were also published separately in the work "Mesmerism, Spiritualism, etc., historically and scientifically considered."

Dr. Carpenter's appointment to the office of Registrar of the University of London, in 1856, gave him more leisure than he had previously enjoyed to pursue his studies systematically and untrammeled by the drudgery of routine duties; and the fruits of the employment of this leisure are seen in the greater fullness and perfection of his scientific work subsequent to that time. He had already, during most of his residence in London, been occupied with the minute study of the calcareous shells of the *Mollusca*, and this had led him to the regular use of the microscope. One of the earlier fruits of these studies was his book on "The Microscope and its Revelations," a manual most highly prized by all followers of the enchanting study of microscopy, of which the sixth edition was published in 1881. Other fruits of them are to be found in his reports on the microscopic structure of shells, which he presented to the British Association from 1844 onward. In these papers much light was thrown on the structure, which was found to be more complex than had been supposed, and the law of growth of shells. His studies in the *Foraminifera*, which were continued through his life, furnished the occasion for several memoirs in the "Philosophical Transactions," and for an illustrated monograph, which was published by the Ray Society in 1862. One of the most interesting of his studies in this line was that on the structure and development of the *Comatula*, or feather-star, in which he proposed a theory of the nervous function of the axial cords running through the arms of the animal, differing from or contradicting the views commonly held. A re-examination of the structure of the animal, and repetition of his experiments, made some five years ago at the Marine Laboratory of Dr. Dohrn, at Naples, and the experiments of other naturalists, have given confirmation to his opinion. Pertaining

to the investigation of the *Foraminifera* and growing out of it, was the part which he took in the discussions respecting the nature of *Eozoön Canadense*, in which he maintained that the fossil in question exhibits the distinctive structure of the shell-substance of the higher *Foraminiferæ*. He was preparing a memoir on this subject, which he left uncompleted at the time of his death.

Dr. Carpenter, with Professor Wyville Thomson, was one of the prime movers of the expeditions for deep-sea research, which have since been so extensively carried on, and have resulted in so great and valuable additions to our knowledge of zoölogy and the physics of the globe. He took part in the earlier expeditions in 1868 and subsequent years, but was not able to go on the Challenger Expedition. He had an important part, however, in collating and formulating the results of the last expedition, and in making them accessible to the understanding of the public. To this series of investigations belong his theories and publications on ocean-currents.

In 1872 Dr. Carpenter was President of the British Association, at its Bristol meeting, and had the pleasure of announcing in his inaugural address the approaching departure of the Challenger on a circumnavigating expedition of at least three years' duration. The subject of his address was "Man as the Interpreter of Nature," and its purpose was to lead the minds of his audience "to the consideration of the mental processes by which are formed those fundamental conceptions of matter and force, of cause and effect, of law and order, which furnish the basis of all scientific reasoning, and constitute the *philosophia prima* of Bacon"; and to show "that those who set up their own conceptions of the orderly sequence which they discern in the phenomena of nature, as fixed and determinate laws, by which those phenomena not only are within all human experience, but always have been and always must be governed, are guilty of the intellectual arrogance they condemn in the systems of the ancients, and place themselves in diametrical antagonism to those real philosophers, by whose comprehensive grasp and penetrating insight that order has so far been disclosed." At the close of his address, having shown how man had arrived at the recognition of the unity of the power of which the phenomena of nature are the diversified manifestations, and how all scientific inquiry now tends toward this point, he declared that the science of modern times had taken a more special direction: "Fixing its attention exclusively on the order of nature, it has separated itself wholly from theology, whose function it is to seek after its cause. In this, science is fully justified, alike by the entire independence of its objects, and by the historical fact that it has been continually hampered and impeded, in its search for the truth as it is in nature, by the restraints which theologians have attempted to impose upon its inquiries. But when science, passing beyond its own limits, assumes to take the place of theology, and sets up its own conception of the order of nature as a

sufficient account of its cause, it is invading a province of thought to which it has no claim, and not unreasonably provokes the hostility of those who ought to be its best friends. For while the deep-seated instincts of humanity, and the profoundest researches of philosophy, alike point to mind as the one and only source of power, it is the high prerogative of science to demonstrate the unity of the power which is operating through the limitless extent and variety of the universe, and to trace its continuity through the vast series of ages that have been occupied in its evolution." In harmony with these views, he has maintained the genetic unity of all organic beings, and has had no difficulty in insisting that evolution is compatible with theism, and in fact gives a stimulus to the religious emotions.

Dr. Carpenter retired from the registrarship of London University in May, 1879, on a pension, and was chosen a member of the senate of the institution. Among the most important incidents of his career as registrar is mentioned the fact that he secured for the study of natural science the recognition it has enjoyed at the university, and the important place it has always held in the examinations. Shortly after his retirement a movement was instituted, with Earl Granville, Sir John Lubbock, and Dr. William Smith at its head, to procure a portrait of him to be presented to the university, as a memorial of his labors in its behalf.

Arduously as Dr. Carpenter was engaged in scientific research, he found time to make himself useful and appreciated in public and social life. He took pleasure in making science intelligible to the public, and for this purpose accepted a part in the management of the Gilchrist trust for popular lectures, and delivered lectures in the Gilchrist and Swiney courses. His articles on the zoetrope and other similar toys, in the "Intellectual Observer," are commended for their clearness, and the same quality of style contributed very largely to make his physiological treatises popular. He took the highest interest in social questions, and was always glad to throw the light of scientific knowledge upon them. He was quick to perceive the evils of indulgence in intoxicating liquors, became an advocate of total abstinence, and lectured on temperance, while he afterward concluded that there was a legitimate use for wine. Upon Dr. Ray Lankester, who knew him from his own boyhood, "he always produced the most vivid impression of a man of indomitable energy, who had accepted as the highest duty and keenest delight of his life the promotion, whether by advocacy or by research, of true knowledge." "No man of science," Dr. Lankester says in another notice of him, "could witness without respect and sympathy the ardent devotion of the veteran naturalist to the cause of scientific progress, and the earnest simplicity of his character." Whatever he said when his researches were the subject of conversation "was admirable, and his willingness to meet fairly an antagonist was no less indicative of the true, single-hearted man of

science than the almost boyish eagerness with which he would rush into the fray."

From a sketch by a member of his own family, published in the Unitarian paper of London, we learn that he was well versed in literature; that he had a keen relish for political memoirs of his own time; that he took a high view of a citizen's obligations; that he was surprised when in Italy by evincing to himself a susceptibility to the enjoyment of art; that he found unfailing recreation in music; that Nature was to him full of charm and delight; that various qualities made him a genial and ever-welcome companion, trusted for his fidelity; that the dominant conception of his life was that of duty; and that he was rich in family affections.

He was a member of the principal learned societies of his own and other countries; he received the Royal medal of the Royal Society in 1861 and the degree of LL. D. at Edinburgh in 1871, and was elected a corresponding member of the Institute of France in 1873. An illustration of the popularizing tendency of his efforts is given in the fact that the Society of Arts opened one of its life-memberships to him in consideration of the valuable assistance he had afforded it when medals were awarded by it for microscopes to be sold to the public at a cheap rate.

Dr. Carpenter's death, which took place on the 10th of November, 1885, was in consequence of injuries received from an accident which occurred while he was taking a vapor-bath. The lamp of the apparatus being out of order, he used instead a gallipot containing alcohol. In his movements while changing position, he overturned the vessel, and was in consequence severely burned about the body, legs, and face, so that he died about four hours afterward.

SKETCH OF JAMES B. EADS.

THE man who devised and furnished our Government with its first and most useful armored steamboats; who built the St. Louis Bridge; who made one of the shallowest mouths of the Mississippi River permanently navigable for the use of ocean-steamers, and who entertains other practical conceptions as grand as these which, by his logical presentation, have won the unqualified indorsement of the ablest of his professional brethren, has a most evident title to recognition in scientific biography.

JAMES BUCHANAN EADS was born in Lawrenceburg, Indiana, May 23, 1820. "He very early," says Dr. Boynton, in the "History of the Navy during the Rebellion," "evinced such a love of machinery as attracted special notice." When only eight years old, he watched with the greatest interest all the machinery to which he had access. When

nine years old the family removed to Louisville. The engine on board the boat excited so much admiration and wonder that the engineer was induced to explain to him the principal parts of the machine. So well did the lad profit by this one lesson in steam-engineering that in little more than two years after he constructed a miniature engine which was worked by steam. When about ten years old, his father fitted for him a small workshop, and there he constructed models of saw-mills, fire-engines, steamboats, steam-engines, electrical and other machines. One of the pastimes of his childhood was to take in pieces and put together again the family clock, and at twelve years he was able to do the same with a patent-lever watch, with no tools but his pocket-knife. When thirteen, misfortune overtook his father, and he had to withdraw from school and work his own way. His parents went to St. Louis in 1833 and he went with them. The steamer was burned in the night on the way there, and he landed barefooted and coatless, on the very spot now covered by the abutment of the great steel bridge which he designed and built. The only opening in the way of business that offered was to sell apples on the street, and by this means, for a few months, he sustained himself and assisted in supporting his mother and sisters. In time he obtained a situation with a mercantile firm, where he remained for five years. One of the heads of the house having an excellent library, gave him access to it, and he used his opportunity well to study subjects bearing upon mechanics, machinery, civil engineering, and physical science. In 1839 he obtained employment as a clerk or purser on a Mississippi River steamer. He again made the best use of his opportunity to acquire that complete knowledge of the great river which he was afterward able to turn to such good account in the noble enterprises he so fortunately carried into effect. In 1842 he constructed a diving-bell boat to recover the cargoes of sunken steamers. This was followed with a boat of larger tonnage, provided with machinery for pumping out the sand and water and lifting the entire hull and cargo of the vessel. A company was formed to operate this device, and it soon had a business that covered the entire Mississippi River, from Balize to Galena, and even branched into some of its tributaries. By his methods, a great many valuable steamers were set afloat and restored to usefulness which it would not previously have been possible to save, as they would have been buried very soon beneath the river-sands. It was while engaged in this business that he gained a thorough knowledge of the laws which control the flow of silt-bearing rivers, and of the Mississippi he was able to say years afterward that there was not a stretch in its bed fifty miles long, between St. Louis and New Orleans, in which he had not stood upon the bottom of the stream beneath the shelter of the diving-bell.

In 1845 he sold out his interest in this company and established in St. Louis the first manufactory of glass-ware west of the Ohio River.

Two years later this enterprise culminated in financial disaster, and left him, at the age of twenty-seven, burdened with debts to the amount of twenty-five thousand dollars. He then returned to the business of raising steamers, removing obstructions from the channel, and improving the harbor of St. Louis. By the great fire of 1849, twenty-nine steamers were burned at the landing of that city, and most of these wrecks had to be removed by him. The capital with which he started again at this business was supplied by his creditors, and amounted to only fifteen hundred dollars. Ten years later he had increased this modest sum to nearly half a million dollars, and had long previously paid off his creditors in full.

His first undertakings in this peculiar and instructive study of hydraulics occurred while he was constructing the first diving-bell boat, not then completed. A barge loaded with about a hundred tons of pig-lead was sunk upon the rapids of the Mississippi River, near Keokuk, in fifteen feet of water. A contract was made for the recovery of this lead. He had had no experience whatever with the submarine armor, or diving apparatus of any kind; but, engaging a diver from the lakes who was familiar with it, with an armor, an air-pump, and a sailor skillful in the use of rigging, he started—at that time only twenty-two years of age—to the scene of the wreck. Obtaining a barge, this was promptly anchored over it, and preparations made for the diver to go to work; but the current was found so exceedingly rapid that it was impossible to use the armor with any safety. A belt around the diver's waist was attached by a cord to the bow of the boat to hold him against the current, and a ladder procured on which the diver undertook to descend, but it was impossible for him to control his body in the current. Determined not to be baffled, Mr. Eads immediately visited the town of Keokuk and purchased a forty-gallon whisky-barrel, with which to improvise a diving-bell. With several pigs of lead secured around one end of the barrel by a net-work of ropes, and with that head taken out, a block and tackle attached to the net-work at the other end, and a temporary derrick erected, he was soon prepared to commence the recovery of the cargo. But the diver demurred and would not descend in this dangerous-looking apparatus. Mr. Eads then set an example which he has followed throughout all his varied experience as an engineer—which was, never to ask a man in his employ to go where he was unwilling to trust his own life. The bell thus suspended was held against the current by a rope which led up to the bow of the barge, and a strap across the lower end of the barrel was used as the seat for the diver in it. He at once got into the diving-bell and ordered his men to lower him down. He had a trace-chain attached to a lead-line, the lower end of the trace-chain having a ring in it, and with this he was readily enabled to form a loop, which was placed over one of the pigs of lead, and at a given signal it was hoisted up. A small cord sufficed to draw

it back to him while he was still in the bell; and in this manner a number of the pigs, weighing seventy pounds each, were recovered before he started to come up—the air-pump all the time supplying him with air. But, in the mean time, having cleared the space beneath the bell, the guy-line moved it farther and farther up-stream, in compliance with his signals, and instead of the line being slacked out again when his men commenced raising the bell, it was held so far forward that the derrick capsized, having no guy to hold it in the opposite direction. His assistants seized the block and tackle and pulled the whisky-barrel up to the surface of the water by hand. But it was so weighted with the lead around it that they could not raise it higher. Not knowing what was the matter, he waited patiently, the air-pump running with redoubled velocity, supplying him with plenty of air. He soon saw the fingers of a man under the chime of the barrel, and, recognizing this as an invitation, he seized the man's hand and got out from under the barrel, much to the delight of all on board. The derrick was then secured against any possible catastrophe occurring again, and, after a number of successful trips to the bottom, the diver was content to do the remainder of the work.

In 1856 Mr. Eads made a proposition to Congress to keep the channels of the Mississippi, Missouri, Ohio, and Arkansas Rivers clear of snags, wrecks, and other obstructions for a term of years. A bill embodying his plans was passed by the House of Representatives, but failed in the Senate for want of action by that body.

In 1857 his health compelled him to retire from business, and four years later he was called upon to render the most signal and brilliant services to his country in its time of extreme need. It was on the 17th of April, 1861, three days after the surrender of Fort Sumter, when Attorney-General Bates wrote to him from Washington: "Be not surprised if you are called here suddenly by telegram. If called, come instantly. Under a certain contingency it will be necessary to have the aid of the most thorough knowledge of our Western rivers and the use of steam on them, and in that event I have advised that you should be consulted."

The dispatch came shortly after the letter. Mr. Eads went immediately to Washington, and, after consulting with the President and Cabinet, prepared the plan he was requested to submit to them for placing gunboats on the rivers, with suggestions as to the kind of boats best fitted for the service, and in regard to the location of batteries to be erected at several points on shore. Shortly afterward he was appointed, with Captain (afterward Rear-Admiral) John Rodgers, United States Navy, to carry into effect the recommendations which he had made, and at once to improvise three war-vessels for service at Cairo. These were the Conestoga, Tyler, and Lexington, and were the first of the large fleet that afterward covered the Mississippi River. The Quartermaster-General issued proposals soon after for the construction

of seven ironclad gunboats. These were designed by Mr. Eads, and he undertook to build them in sixty-five days—a short enough time under the best of circumstances; but business was then disorganized and all industrial enterprises in a chaotic condition. The materials with which the work was to be done had to be manufactured. Yet these seven heavily-plated vessels of about six hundred tons each were all finished according to contract, and another one still larger, a snag-boat, was by alterations and heavy plating made ready with the others for their armament. "Thus one individual put into construction and pushed to completion within a hundred days a powerful squadron of eight steamers aggregating five thousand tons, capable of steaming at nine knots per hour, large, heavily armed, fully equipped, and all ready for their armament of one hundred and seven large guns. The fact that such a work was done is nobler praise than any that can be bestowed by words."*

In 1862 Mr. Eads was commissioned to build six more armored iron gunboats, four of which were much larger than any of the eight preceding ones. These were likewise after his own designs, four of them having two turrets each and the smaller ones one turret each. These turrets were a modification of the Ericsson turrets, the Government insisting upon these being placed upon them. He was, however, permitted to place one turret on each of two of these large gunboats, after his own design, and costing about thirty-five thousand dollars each, but on the written condition that they should be replaced by Ericsson turrets if they were not found satisfactory. The guns in these two turrets were worked by steam, and this was the first time in the history of artillery-practice when heavy guns were manipulated wholly by steam. These vessels all proved to be of lighter draught than had been stipulated, so that it was possible to add from half to three quarters of an inch to their armor; and three of them exceeded very considerably the contract speed. While these fourteen ironclads were under way, Mr. Eads also had the construction of four heavy mortar-boats and seven tin-clad or musket-proof boats. The kind of ironclads that Mr. Eads designed and constructed and the kind of work they did are recorded in the history of Grant and Halleck's campaigns, and of Farragut's capture of Mobile.

In the construction of a steel-arch bridge at St. Louis, on which he was engaged from 1867 to 1874, Mr. Eads had to deal with problems which had not before confronted an engineer. The central arch of this structure has a clear span of five hundred and twenty feet, and is pronounced, by the "British Encyclopædia," the finest specimen of metal-arch construction in the world. The side arches are five hundred and two feet each in span. All of the piers, in consequence of the shifting deposits beneath the river-bed, were sunk clear through to the bed-rock. This required them to be sunk much deeper than

* Boynton's "History of the Navy during the Rebellion."

any piers ever built, and through a medium of the most treacherous character. New plans had to be devised to secure success. One pier, weighing forty-five thousand tons, was sunk to a depth of one hundred and thirty-six feet below high-water mark through ninety feet of sand and gravel; and another one, weighing forty thousand tons, to one hundred and thirty feet through eighty feet of deposit. The loss of life which occurred in the caisson of the east pier resulted from the fact that the situation at such a depth, with the air-pressure it was necessary to endure, was entirely new, and there was no recorded experience by which operations could be guided safely. The erection of the arches developed new problems. The arches had to be designed about two and a half inches longer than they are in their present position, because of the contraction which their weight causes throughout the arch. Each half of the arch was built out from the pier and suspended by guys passing through heavy masts erected on each pier, and the central tubes had to be specially fitted for insertion. The suggestion was made by his chief assistant to contract the tubes by boxing them up and covering them with iron. This Mr. Eads disapproved of, and devised telescopic tubes for the center of the arch which could be shortened by an internal right and left hand screw-plug, and afterward extended by powerful levers to rotate this plug, steel bands being also provided to cover the plug, flush with the outside of the tube, when the tubes were properly distended. During his absence in London, the chief assistant, confident of his ability to close them with ice, and, having been left with full authority, undertook to do so; but the attempt proved a failure after a trial of eight or ten days, and the telescopic tubes, which Mr. Eads had prepared, were then inserted without difficulty.

In an address delivered at the opening of this bridge, July 4, 1874, Mr. Eads revealed that confidence in his resources and investigations which probably furnishes one of the keys to the secret of his success in this and in his other enterprises. This secret consists in the fact that his courage is always equal to his convictions. Everything, he said, on this occasion, which prudence, judgment, and the present state of science could suggest to him and his assistants had been carefully observed in its design and construction; every computation involving its safety had been made by different individuals, thoroughly competent to make them; they had been carefully revised, time and again, re-examined, verified, until the possibility of error nowhere existed.

A similar confidence was displayed in his plans for deepening the mouth of the Mississippi by jetties, in which he was opposed by nearly all of the United States engineers, and by a commission of seven of them. The commission in 1874 proposed to avoid the bars by building a canal from Fort St. Philip to Breton Bay. Mr. Eads's plan was to make the river itself deepen a channel through them. Congress

naturally inclined to adopt the advice of its official experts, but Mr. Eads had faith enough in his plan to propose to do the work at his own expense and wait for his pay until he had demonstrated its success. It was hard to get permission to make even the experimental application of his views thus so liberally proposed; but a bill was finally passed to allow him to attempt the improvement of the South Pass, the smallest of the three, and not the one he had selected, and the depth on the bar of which was only eight feet. The cost of the work was to be five and a quarter million dollars; only half a million was to be paid after a channel twenty feet deep by two hundred feet in width had been secured, another half million after a channel twenty-two feet deep, and other sums on the obtaining of channels of twenty-six and twenty-eight feet depth respectively; but, as a guarantee that the maintenance of the channel should not cost more than one hundred thousand dollars a year, the final million of the whole sum was to be withheld until a channel of thirty feet maximum depth had been kept throughout during twenty years. Congress, however, deeming these terms unnecessarily severe, with remarkable unanimity voted to pay him one and three-quarter million dollars in advance of his contract terms, after he had secured twenty-two feet depth.

The conception of the plan of the jetties was based upon a knowledge of the fact that the Mississippi River is a transporter of solid material, almost all of which is held in suspension by the mechanical effect of the current, and that the quantity of the matter which it is able to carry increases with the square of the velocity. The current of the river is caused by the fall of the water from a higher to a lower level; that is, by the force of gravity. The element which resists the current is the friction of its bed; this friction does not follow the law of solids, but increases or diminishes exactly as the width of the bed or wetted perimeter of its cross-section is increased or diminished: hence, if the stream be contracted, where it is too wide, to one half its width, one half of the frictional resistance will be gone, and the current will be more rapid, and therefore more able to carry a larger load of sediment. This it immediately takes up from its own bed and thus causes a deepening. The result of the application of the jetty system to the South Pass has been a triumphant justification of its author's views.

On the 8th of July, four years after he commenced the work at the jetties, the United States inspecting officer reported that the maximum depth of thirty feet had been secured throughout the jetty channel, and that the least width of the twenty-six-feet channel through the jetties was two hundred feet. The balance due Mr. Eads upon his contract was then paid to him, and the million that was to be held as security for maintenance was considered as earned, and placed at interest for his benefit. The current of the river has maintained this depth ever since. The cost of the jetties was about half of the estimated cost of the proposed canal.

Mr. Eads had not commenced the jetties before he turned his attention to the improvement of eleven hundred miles of the Mississippi throughout its alluvial basin by the jetty system. On March 15, 1874, in a letter to the Hon. William Windom, chairman of the Senate Committee on Transportation Routes to the Seaboard, the first outline of this novel plan was suggested.

In his review of the United States Levee Commission, February 19, 1876, Mr. Eads said :

"By the under-charge theory of the Delta Survey Report, caving banks are attributed to the direct action of the current against them, by which strata of sand underlying those of clay are supposed to be washed out. This is not correct. If the water be charged with sediment to its normal supporting capacity, it can not take up more unless the rate of current be increased. Caving banks are caused wholly by the alternations in the velocity of the current. Alternations are inseparable from a curved channel, because the current in the bend is usually more rapid than on the point ; but, if the channel be nearly uniform in width, the caving caused by the curves will be very trifling. And, in proof of this, many abrupt bends exist in the lower part of the river where the whole force of the current has set for years directly against them without any important caving of the banks. The bend at Fort St. Philip is a notable instance, the great difference in the width of the flood-channel constituting the real cause of the destruction and caving of the banks. This tends to great irregularities in the slope of the flood-line, and, consequently, great changes in current velocity by which a scouring and depositing action are alternately brought into very active operation. The whole of the river below the Red River proves this ; caving banks are much less frequent there than above, because the flood width of the river is far more uniform. A correction of the *high-water channel*, by reducing it to an approximate uniformity of width, would give uniformity to its slope and current, almost entirely preventing the caving of its banks, and through its present shallows, which now constitute the resting-places for its snags, there would be a navigable depth, in *low water*, equal to that which now exists in its bends. By such correction the flood-slope can be permanently lowered, and in this way the entire alluvial basin, from Vicksburg to Cairo, can be lifted, as it were, above all overflow, and levees in that part of the river rendered useless. *There can be no question of this fact, and it is well for those most deeply interested to ponder it carefully before rejecting it ; for the increased value given to the territory thus reclaimed can scarcely be estimated.*"

Two years later, in a review of Humphreys and Abbott's "Report on the Physics and Hydraulics of the Mississippi River," published in Van Nostrand's "Engineering Magazine," Mr. Eads elaborated this plan, and combated the declaration that the bed of the river is formed of blue clay and will not erode unless very slowly under the effect of

the current, and likewise exposed the fallacy of the declaration that there is no relation between the quantity of sediment carried in the water and the velocity of its current.

Mr. Eads thus clearly outlined, in 1874, 1876, and 1878, one of the most magnificent plans which hydraulic engineering has ever undertaken. It is not simply to save thirty thousand square miles of land as rich as the Delta of Egypt from devastating inundations, but to extend deep water from the Gulf of Mexico to the mouth of the Ohio, into the very heart of the Mississippi Valley, while permanently locating this magnificent channel by practically putting an end to the caving of its banks. During the period we have referred to, Mr. Eads delivered addresses upon this subject in the chief cities of the river, published elaborate essays in which it was fully explained, and defended it against all attacks, until finally, in 1879, Congress authorized the creation of a commission to consider this plan, which is known as the "jetty system." The "outlet system" and the "levee system" were also examined by it, and in 1880 it reported in favor of the "jetty system," and recommended its adoption by Congress in its report, February 17, 1880. Mr. Eads was a member of the commission for two or three years. During this period, several million dollars were voted by Congress to carry out the plan, which will be found described in the report referred to, as agreeing substantially with the quotations we have made. Two reaches of the river, Plum Point, twenty miles long, and Lake Providence, thirty-five miles long, were selected for improvement; the low-water depth in the first reach was only five feet, the other reach (four hundred miles below) had a depth of only six feet. The permeable contraction-works, constructed of piles and willows, which had been first used by Mr. Eads at the South Pass several years before, were put in position for one season in the period between two floods, and the effect produced by the works during the first flood that followed was simply marvelous. The depth was increased through the upper reach to twelve feet at low water, and through the lower reach to fifteen feet, and scores of millions of cubic yards of sediment were deposited between them by the checking of the current by the permeable works. Thus new shore-lines of an approximately uniform width were developed. In some places the deposit was thirty feet deep.

Mr. Eads was, during the time of this construction, in bad health, and for some time absent from the United States. Owing to the charge made by several prominent friends of the river (members of the Senate and House), that the commission had abandoned the leading feature of the system, the contraction-works, and had changed it to a costly system of bank-revetments, and the public declarations of Mr. Eads to the same effect, no further appropriations were made at the last session of Congress to continue this magnificent work; enough has been done, however, to show the entire practicability of the plan.

Mr. Eads claims that this system of improvement designed by him is, in several respects, wholly different from any ever before proposed for the treatment of a river; it is, however, only applicable to rivers flowing through alluvial deposits.

The grandest work, however, contemplated by Mr. Eads, is the ship-railway which he proposes to construct across the Isthmus of Tehuantepec, for the transportation of large ships fully laden from ocean to ocean. This he holds to be entirely practicable—because the railway can be built wherever the canal can, at one half the cost of the canal with locks, or one quarter the cost of one at tide-level; because it can be built in one third or one quarter of the time needed to build a canal; because four or five times the speed practicable on a canal can be secured; because more vessels can be carried in a day over the railway than through the canal; because the capacity of the railway can be increased to suit increased needs without disturbance; because it will cost less to maintain and operate it than to maintain and operate a canal; because it can be built and operated where the canal can not be; because more accurate estimates can be made of the cost and time needed for its construction; and because its location is the very best of all those which are proposed on the American Isthmus. It is not generally known, but it is nevertheless true, that the location of the ship-railway and that of the Panama Canal are about twelve hundred statute miles apart, the whole immense territory of Central America lying between the two. It is, therefore, far superior in climate and in position to any other location.

Besides these works, Mr. Eads has, at the request of the Governments and individuals particularly interested, examined and reported upon the bar at the mouth of the St. John's River, Florida, the improvement of the Sacramento River, the improvement of the harbor of Toronto, the improvement of the port of Vera Cruz, the improvement of the harbor of Tampico, the improvement of the harbor of Galveston, and the estuary and port of the Mersey, England. He was President of the St. Louis Academy of Science for two terms, and made an inaugural address in which was embodied a review of the recent achievements of science, and, in another, the present knowledge of the laws of light. In 1881 he made an extemporary address before the British Association at York, upon the improvement of the Mississippi, and also upon the Tehuantepec Ship-Canal, which were, by unanimous vote, ordered to be embodied in its report of the proceedings; and in June, 1881, he was awarded the Albert Medal of the British Society of Arts, in token of its appreciation of the services he had rendered to the science of engineering—he being the first American upon whom this medal had been conferred. It is now his purpose to devote the remaining energies of his life, until the scheme is an accomplished fact, to the prosecution of the Ship-Railway.

EDITOR'S TABLE.

BEECHER'S POSITION ON EVOLUTION.

TWO great standards of truth have prevailed in the world; truth according to nature and truth according to theology. Truth according to nature has been held as of little moment, because all its consequences are temporal and transitory; but truth according to theology has been held as of infinite importance, because salvation and the interests of an immortal destiny depended upon it. There was, therefore, but little chance for getting up much interest in the truth of things natural so long as the theological standard of truth was supreme. Galileo made a book stating the evidence of the Copernican system of astronomy according to the facts of nature; but he was summoned before the inquisitorial court to answer the charge of heresy for not judging of the scheme of the planetary motions by the standard of theological authority. Truth according to nature in those days went for very little in comparison with truth according to the supernatural. Theological ideas were in the minds of everybody, were held of transcendent importance, and everything in the shape of new knowledge was first brought to the test of agreement with authorized religious doctrine.

Two or three centuries have made great changes in this matter. The theological standard has been lowered, and a much higher value is set on the truth which agrees with nature; but multitudes of minds are still dominated by theological conceptions, and when new ideas are proposed instead of asking whether they agree with the facts or are true to the nature of things, the first question is, as it was three hundred years ago, How do these ideas agree with prevailing religious opinions? The illustrations of this survival of the theological spirit and methods are still numerous, and a fresh example has recently come to our attention which will well serve to bring out the point we have in view in the present article. It consisted of a vigorous attack on Mr. Beecher's book, "Evolution and Religion," which appeared in the "Commercial Advertiser" of November 20th. The point of view is thoroughly mediæval, the writer seeming to care but very little as to whether evolution is true or not, but to be profoundly concerned about theology's relation to it. The writer condemns Mr. Beecher for refusing to judge of the doctrine of evolution on the basis of its agreement or non-agreement with the old middle-age standards of religious dogma. He says: "Of course Mr. Beecher, like anybody else, may put what construction he pleases on the doctrine of evolution, and he may put a construction to suit him on the doctrines of theology, and in that way patch up a sort of reconciliation: and that is precisely what he does. . . . At the same time he contrives a religion which is certainly not the religion of the fathers, or of the martyrs, or of the ancient confessors, or of any of the accepted symbols of the Church." From which we are to infer that the theology of the fathers and of the martyrs and of the ancient confessors or old cast-iron middle-aged orthodoxy, is to be taken as the standard of truth, and the doctrine of evolution judged by its agreement with that standard. That the writer should argue that the doctrine of evolution is materialistic and atheistic is quite a matter of course; but what we wish to call attention to here is, that he seems to have but little more care as to whether this doctrine is true to the realities of nature than had the old inquisitors in relation to the new astronomy. Indeed, toward

the close of his article he has the following contemptuous reference to this point: "We are not going to argue here the truth or falsehood of the unverified and unverifiable hypothesis which is palmed upon us in the name of science." Still, we think that the question of "truth or falsehood" in so important a case is one that might well have been settled first. If the theory of evolution, as the writer declares, "has been reached in utter defiance of the canons of scientific method," it would have been well to show this at the outset. Besides, if the doctrine is an imposture, "which is palmed upon us in the name of science," it would be interesting to have it pointed out by what extraordinary hocus-pocus the scientific men of the present age have been imposed upon in accepting it.

To us the chief interest of Mr. Beecher's position, assumed in his recent books, is as a register of the rising influence and increasing power of scientific ideas and the corresponding decline of theological authority. He has passed far beyond the stage in which he asks first whether new ideas agree with old creeds. Although a professed theologian, he has so thoroughly entered into the spirit and method of modern science as to recognize that the supreme question in this case is whether the doctrine of evolution is an expression of the truth of nature. Mr. Beecher has by no means repudiated theology, but he has taken the great step of subordinating it to the standards of truth established by investigation and the study of the order and economy of the existing world. The old notion of two sets or systems of truth, one of which has claims of a special sacredness and superiority, while the other is profane, secular, and of merely human origin, and therefore of inferior rank, we understand him to repudiate. He finds the sacredness of authority in the truth itself, and none the less because man discovers and establishes it by his own faculties. Mr. Beecher, therefore, represents in an eminent way that vast change or revolution of modern thought which gives a higher value and a nobler significance to the study of nature and the revelation of the truths of nature. Nor in thus giving his highest allegiance to natural truth as disclosed by the workings of the human mind can he be said to have rejected religion or left the religious sphere. Holding firmly to theism, he simply maintains that the truth and order and harmony of nature are the highest manifestations of the attributes of God.

Mr. Beecher reconstructs the old theology, rejecting large portions of it which have formerly been held as essential, and reshaping what remains so as to bring it into better agreement with modern scientific ideas. As an honest and conscientious man he found no escape from entering upon this work. Only as an indifferentist, or a trifler, or a theologian enslaved to his traditions, could he recognize the great changes wrought by modern science, without any concern for those readjustments of human belief which have become inevitable. His book is full of evidences of that sincerity and earnestness of feeling upon the subject which have impelled him to undertake the task of working out the religious bearings of the doctrine of evolution. He saw that it had taken root in the best intelligence of the civilized world. There was no blinking or evasion of the facts that had to be met. The strong men of all nations who give their lives to the study of nature, the devotees of research, and the investigators of original truth in all departments of natural phenomena had come to agreement over this great principle with a rapidity and a unanimity such as has never before been seen in the history of science. There had been a vast accumulation of observations, facts, and principles in every department of research which defied explication and organization until the law of evolution was grasped and applied to them, and,

under the light it afforded, the work of research went on with increasing fruitfulness and success. The doctrine of evolution was not merely acknowledged, but it became a new guide to the discovery of truth, which is the highest possible attestation that could be given of its verity. Nor was it by any means a mystery of experts confined to laboratories of which ordinary people could know nothing and must take on authority. Its illustrations and proofs constantly multiplied in those common spheres of thought with which intelligent people are familiar, so that the current literature of the time was full of it. Mr. Beecher saw that the doctrine was not only accredited by a very large number of the ablest minds of the age as an established truth, but he had himself been a student of the subject in his own field of labor, and he found it of invaluable service in that revision of beliefs and opinions which was a part of his responsible duty as an independent public teacher. In broadly accepting and comprehensively applying the new doctrine, Mr. Beecher gives a powerful impulse to theological reform, for, in the further winnowing of religious opinions, only those will stand which are found vitally rooted in the truths of nature; and, from this point of view, the acceptance of the doctrine of evolution by the religious mind will be the most important step yet taken in renovating theology by ending its antagonism with the order of natural truth, and by making "the solid ground of nature" its lasting and unshakable foundation.

LITERARY NOTICES.

LOUIS AGASSIZ: HIS LIFE AND CORRESPONDENCE. Edited by ELIZABETH CARY AGASSIZ. In two volumes, pp. 794. Boston: Houghton, Mifflin & Co. Price, $4.

MRS. AGASSIZ began the preparation of this extremely interesting biography with the simple purpose of preserving the facts, letters, and journals bearing upon it from dispersion and final loss. But, as the work grew in her hands, she says she began to feel that an intellectual life, marked by such unusual coherence and unity of aim, might serve as a stimulus and an encouragement to others. And, for this reason, she at length decided to place it before the general public. The first volume contains a portrait of Agassiz at the age of nineteen, and several other interesting illustrations connected with his birthplace and early life. The narrative in this volume covers the European portion of Agassiz's life, about which little is known in this country. It is woven together from family papers, and the contributions of fellow-students and others who knew Agassiz intimately at one period or another of his early career. A brother of Professor Agassiz, who survived him several years, took the greatest interest in preserving whatever concerned his scientific career, and this brother furnished Mrs. Agassiz with many papers and documents concerning his earlier life. After the brother's death the work was continued by a cousin, Mr. Auguste Mayor, who also selected from the glacier of the Aar, "at the request of Mr. Alexander Agassiz, the bowlder which now marks his father's grave."

Louis Agassiz had no other teacher than his parents for the first ten years of his life. "Having lost her first four children in infancy, his mother watched with trembling solicitude over his early years." She understood that his love of nature was an intellectual tendency, and throughout her whole life, as well in the work of his manhood as in the sports of his childhood, she remained his most intimate friend. He survived her but six years. When a very little fellow he had his collection of fishes, and the vignette represents the stone basin behind the parsonage, into which water from a spring was always flowing, and which was Agassiz's first aquarium. He had various pets, whose families he reared with the greatest care. "His pet animals," we are told, "suggested questions to answer, which was the task of his life." The story of his school-life, from the age of ten to seventeen, is briefly told, but leaves the distinct impression of a boy with a settled purpose. After spending two years at the medical school in Zürich, Agassiz went to the University of

Heidelberg in the year 1826, at the age of nineteen. It is not easy to make citations from a book of such uniform interest; but his student-life at Heidelberg, and afterward at Munich, as gathered from various passages in this history, has a peculiar fascination. In one of the first acquaintances made by him at this time, Agassiz found a life-long friend—

and in after-years a brother. Professor Tiedemann, by whom he had been so kindly received, recommended him to seek the acquaintance of young Alexander Braun, an ardent student and especial lover of botany. At Tiedemann's lecture, the next day, Agassiz's attention was attracted by a young man who sat next him, and who was taking very careful notes, and illustrating them. There was something very winning in his calm, gentle face, full of benevolence and intelligence. Convinced, by his manner of listening to the lecture, that this was the student of whom Tiedemann had spoken, Agassiz turned to his neighbor, as they both rose at the close of the hour, and said, "Are you Alexander Braun?" "Yes. Are you Louis Agassiz?" . . . The two young men left the lecture-room together, and from that time their studies, their excursions, their amusements, were undertaken and pursued together. . . . Braun learned zoölogy from Agassiz, and he in turn learned botany from Braun.

In a letter of young Braun to his parents, written at this time, he says:

In my leisure hours I go to the dissecting-room, where, in company with another young naturalist, who has appeared like a rare comet on the Heidelberg horizon, I dissect all manner of beasts, such as dogs, cats, birds, fishes, and even smaller fry, as snails, butterflies, caterpillars, worms, and the like. . . . I sometimes go with this naturalist on a hunt for animals and plants. Not only do we collect and learn to observe all manner of things, but we exchange views on scientific matters in general.

And he adds, concerning Agassiz's attainments at this time:

I learn a great deal from him, for he is much more at home in zoölogy than I am. He is familiar with almost all the known mammalia, recognizes the birds from far off by their song, and can give a name to every fish in the water. In the morning we often stroll together through the fish-market, where he explains to me all the different species. He is going to teach me how to stuff fishes; and then we intend so make a collection of all the native kinds. Many other useful things he knows; speaks German and French equally well, English and Italian fairly, is well acquainted with ancient languages, and studies medicine besides. . . . To utilize the interval spent in the time-consuming and mechanical work of preparing specimens, pinning insects, and the like, we have agreed that, while one is employed, the other shall read aloud. In this way we shall go through various works on physiology, anatomy, and zoölogy.

They spent their vacations together; "drew, studied, dissected, arranged specimens, discussed theories with their young brains teeming about the growth, structure, and relations of animals and plants." Another young botanist, Karl Schimper, was taken into this Heidelberg intimacy, and the three were inseparable in their studies. At one time Agassiz was kept at home in Switzerland by sickness, but the letters passing between these fellow-inquirers were remarkable. Here is a set of questions propounded by Agassiz to Braun and Schimper at Heidelberg. He was studying the fishes of the Swiss lakes and trying to catalogue them, and he says:

As I am on the chapter of fishes, I will ask you—1. What are the gill-arches? 2. What the gill-blades? 3. What is the bladder in fishes? 4. What is the cloaca in the egg-laying animals? 5. What signify the many fins of fishes? 6. What is the sac which surrounds the eggs in bombinator obstetricians? [a creature about which there had been former correspondence].

Braun, on his part, writes to Agassiz: "On my last sheet I send some nuts for you to pick, some wholly, some half, others not at all cracked." The following are some of the mooted questions:

1. Where is the first diverging point of the stems and roots in plants, that is to say, the first geniculum?
2. How do you explain the origin of those leaves on the stem which, not arising from distinct geniculi, are placed spirally, or scattered round the stem?
3. Why do some plants, especially trees (contrary to the ordinary course of development in plants), blossom before they have put forth leaves (elm-trees, willow-trees, and fruit-trees)?
4. In what succession does the development of the organs of a flower take place—and their formation in the bud? (compare campanula, papaver).
5. What are the leaves of the spergula?
6. What are the tufted leaves of pine-trees?
7. What is individuality in plants?

It matters not that most of these problems were solved long ago; they no less illustrate the action of these young minds in carrying forward their fruitful studies. It is to these two botanists, Braun and Schimper, that botany owes the discovery of the law of Phyllotaxis which is hinted at in the first of the above questions. We next find the three friends established at Munich, attending the lectures of Döllinger, Martius, Schelling, Oken, the latter of whom was extremely friendly with them, inviting them once a week to his house,

where they listened to scientific papers or discussed scientific matters. They took tea once a week with Professor von Martius, while with Döllinger they were still more intimate. "Not only did they go to him daily, but he often came to see them, bringing botanical specimens to Braun, or looking in upon Agassiz's breeding experiments, in which he took the liveliest interest, being always ready with advice and practical aid. The fact that Agassiz and Braun had their room in his house made intercourse with him especially easy. This room became the rendezvous of all the aspiring, active spirits among the young naturalists at Munich, and was known by the name of 'The Little Academy.' . . . The friends gave lectures in turn on various subjects, especially on modes of development in plants and animals. These lectures were attended not only by students, but often by the professors." In a letter to his father, Agassiz describes his life at this period as exceedingly pleasant. He says:

When our lectures are over, we meet in the evening at Braun's room or mine, with three or four intimate acquaintances, and talk of scientific matters, each one in his turn presenting a subject which is first developed by him and then discussed by all. These exercises are very instructive. As my share, I have begun to give a course of natural history, or rather of pure zoölogy. Braun talks to us of botany, and another of our company, Mahir, who is an excellent fellow, teaches us mathematics and physics in his turn. In two months Schimper will join us and become our professor of philosophy. Thus we instruct each other, learning what we teach more thoroughly because obliged to demonstrate it. Each session lasts two or three hours, during which the professor in charge retails his merchandise without aid of notes or book. You can imagine how useful this must be in preparing us to speak in public and with coherence; the experience is the more important, since we all desire nothing so much as sooner or later to become professors in very truth.

Again, in writing to his father, Braun says of these private lectures:

Sometimes Agassiz tries to beat French rules and constructions into our brains, or we have a lesson in anatomy, or I read general natural history aloud to William Schimper. By-and-by I shall review the natural history of grasses and ferns, two families of which I made a special study last summer. Twice a week Karl Schimper lectures to us on the morphology of plants. He has twelve listeners. Agassiz is also to give us lectures occasionally on Sundays upon the natural history of fishes.

An artist who was already in the employ of Agassiz, and who afterward made the illustrations of his works upon fossil fishes, describes Agassiz's life and surroundings at this time as follows:

He never lost his temper, though often under great trial. . . . His studio was a perfect German student's room. It was large, with several wide windows; the furniture consisted of a couch and about half a dozen chairs, besides some tables, for the use of his artists and himself. Alexander Braun and Dr. Schimper lodged in the same house and seemed to me to share his studio. Being botanists, they too brought home what they collected in their excursions, and all this found a place in the atelier, on the couch, on the seats, on the floors. Books filled the chairs, one alone being left for the other artists, while I occupied a standing desk with my drawing. No visitor could sit down, and sometimes there was little room to stand or move about. The walls were white, and diagrams were drawn upon them, to which by-and-by we artists added skeletons and caricatures. In short, it was quite original.

The second volume is devoted to Agassiz's life in America. The frontispiece is a portrait taken at the age of fifty-five, and bringing at once to mind the features so well known to multitudes of people in all parts of the country. Besides the vignette, showing us the laboratory at Nahant, there is a view of the cottage at Nahant, of the Museum of Comparative Zoölogy, a portrait bust by Powers, and a view of Penikese.

SCIENTIFIC THEISM. By FRANCIS ELLINGWOOD ABBOT, Ph. D. Boston: Little, Brown & Co. Pp. 219. Price, $2.

THIS work is an attempt at developing theism from science and the scientific method. Dr. Abbot criticises nominalism and conceptualism, and argues for a noumenism in which every phenomenon is, as far as it goes, a real revelation of the noumenon. He holds that the mind perceives true relations in nature, and that therefore to the extent to which human knowledge has gone it forms a part, however small, of that contained in the Divine Mind. The theory of the unknowable the author rejects, holding that absolute knowledge of a thing would consist in knowing the sum of its relations to all other things in the universe.

Dr. Abbot argues from the intelligibility of the universe to its intelligence; and hence, since it is all-inclusive, to its self-consciousness. His is no external deity related to the universe, as machinist to machine, but the immanent mind, whose organic life and growth, manifested to us in nature,

is none other than evolution, which has dawned upon the investigators and thinkers of to-day.

ON POLYSYNTHESIS AND INCORPORATION AS CHARACTERISTICS OF AMERICAN LANGUAGES. By DANIEL G. BRINTON, M. D. Philadelphia. Pp. 41.

DR. BRINTON appears to have struck upon an undeveloped mine of linguistic research. Philologists have told us of monosyllabic, agglutinative, and inflectional languages, and of analytic and synthetic languages, and we have means in the libraries of books they have written upon them of learning all about them. The American languages, according to the present author, present entirely different types—those named in the title above—which have so far been only vaguely described, probably because they were only vaguely understood. Polysynthesis, according to Dr. Brinton, is a method of word-building which employs juxtaposition of words with the modifications they usually undergo when brought together, and also words, forms of words, and significant phonetic elements which have no existence apart from the compounds into which they enter. By incorporation, the nominal and pronomial elements of the proposition are subordinated to the verbal elements, and either have no independent existence in the form required by the verb, or are included within the specific verbal signs of tense and mood. By the use of these methods, of which various illustrative examples are given from several languages, the whole sentence is woven into a single word. These peculiarities constitute the American languages a distinct and independent class.

CONSANGUINEOUS MARRIAGES: THEIR EFFECT UPON OFFSPRING. By CHARLES F. WITHINGTON, M. D. Roxbury, Massachusetts. Pp. 32.

DR. WITHINGTON inquires into the validity of the belief that consanguinity of parents is in and of itself detrimental to offspring. He finds the evidence usually presented in favor of that opinion insufficient to demonstrate it. He presents evidence collected by himself, which, while he is far from regarding it as decisive, seems to go a great way toward justifying a negative view of the case.

BAD TIMES. An Essay on the Present Depression of Trade, tracing it to its Sources in Enormous Foreign Loans, Excessive War Expenditure, the Increase of Speculation and of Millionaires, and the Depopulation of the Rural Districts. With Suggested Remedies. By ALFRED RUSSEL WALLACE, LL. D. New York: Macmillan & Co. Pp. 118. Price, 75 cents.

A PREMIUM was offered in England, known as the "Pears Prize," of one hundred guineas for the best essay on the depression of trade. Mr. Alfred Russel Wallace, the celebrated naturalist and philosophic thinker, who anticipated the chief work of Darwin, competed for it. It was, of course, thought singular that a traveling naturalist, a collector of butterflies, and an investigator on the origin of species, should have the assurance to strike into the great field of finance and international trade relations with a view of determining the causes of the present extensive hard times. But Mr. Wallace was not unprepared for the task. In his early life he had spent twelve years as a land surveyor and valuer, when he had much observation of agricultural life, and became familiar with a wide range of facts which had a bearing upon the land question now so prominent, and all of which gave a turn to his thought that well prepared him to take up the present discussion. But Mr. Wallace did not get the prize. His independent handling of the general subject, the deviation of many of his views from orthodox lines, and the introduction of new and more comprehensive causes of the prevailing bad times, probably explained the failure of his essay before the committee of award.

But the book is none the less valuable because uncrowned with a golden prize, and he did well to have it printed. In reviewing his previous works we have had repeated occasion to speak of his power as a clear thinker and lucid writer, and the present volume illustrates these traits as signally as anything he has previously done. He first states the general problem, and then considers the popular explanations for the extensive business depression, which is followed by the criteria indispensable to a true explanation. In successive chapters he takes up the baneful influence of extensive foreign loans, both upon England

and the numerous countries which have received her capital. Prominent among the causes of business calamity he discusses the recent increase of war expenditures, rural depopulation, pauperism in England and Ireland, bad agricultural policy, millionaires as a cause of depression, speculation and finance, adulteration and dishonesty. In Part II several brief chapters are devoted to the suggestion of remedies.

The view taken by Mr. Wallace is broad and very instructive. His facts are copious and pertinent, and the reasoning cogent and forcible. His ideas are far more elevated and philosophical than we are accustomed to in treating this class of questions. This well appears in his closing paragraphs. He says: "In conclusion, I wish to direct my readers' attention to a very suggestive fact elicited by our present inquiry, and which appears to me to express the moral teaching of the whole subject. In every case in which we have traced out the efficient causes of the present depression, we have found it to originate in customs, laws, or modes of action which are ethically unsound, if not positively immoral. Wars and excessive war armaments, loans to despots, or for war purposes, the accumulation of vast wealth by individuals, excessive speculation, adulteration of manufactured goods, and lastly, our bad land system, with its insecurity of tenure, excessive rents, confiscation of tenants' property, its common-inclosures, evictions, and depopulation of the rural districts—all come under this category; while the one apparent exception, the bad seasons, would have been comparatively harmless (as instances here quoted have shown) under a thoroughly good system of land-tenure.

"We thus see that the evils under which we have suffered, and are still suffering, are due to no recondite causes, to no laws of inevitable fluctuation of trade, but wholly to our own acts, and to those of other civilized nations. Whenever we depart from the great principles of truth and honesty, of equal freedom and justice to all men, whether in our relations with other states, or in our dealings with our fellow-men, the evil that we do surely comes back to us, and the suffering and poverty and crime of which we are the direct or indirect causes, help to impoverish ourselves. It is, then, by applying the teachings of a higher morality to our commerce and manufactures, to our laws and customs, and to our dealings with all other nationalities, that we shall find the only effective and permanent remedy for depression of trade."

OVERPRESSURE IN SCHOOLS, pp. 11; SANITARY SCIENCE AND PUBLIC HYGIENE, pp. 9. By W. S. ROBERTSON, M. D. Muscatine, Iowa.

THE author of these papers is President of the Iowa State Board of Health, and in the essays discusses two very important points in public hygiene. The former paper relates to the effects of overpressure upon the health and progress of school-children, and the signs by which its evil workings may be discovered. The second paper relates to the importance of diffusing sound information among the people, in order that they may recognize the value of sanitary science, and may learn how to participate in its benefits.

AMERICAN CONSTITUTIONS. By HORACE DAVIS. Baltimore: N. Murray. Pp. 70. Price, 50 cents.

THIS is one of the Johns Hopkins University studies in historical and political science. Its purpose is to follow the changes in the relations of the three departments of government—legislative, executive and judicial—which have been silently going on in the United States for the past century. In the State governments, under numerous alterations in their Constitutions, the powers of the Executive have been steadily enlarged, and the functions of the Legislature have been cramped and limited; in the Federal Government, Congress has encroached upon the field of Executive power; and everywhere, in both national and State governments, the judiciary has gained vastly in power and importance. The author believes that there have been three distinct strata of government in the old thirteen colonies. In the first or colonial period, the Executive was too strong; in the second, the Legislature; in the third, the balance was restored, and our State Constitutions are to-day, he believes, "as a whole, the most perfect framework of government for men living in a democracy, that human skill has ever devised."

NEW YORK AGRICULTURAL EXPERIMENT STATION. Third Annual Report of the Board of Control, for 1884. Albany: Weed, Parsons & Co. Pp. 424, with Plates.

THE station is reported as now better equipped for its work than at any previous period. Not only have the apparatus for scientific and practical work been provided, but information has been and is being acquired regarding the condition of our soil and climate. The work at such a station is necessarily cumulative in its character, and each year must mark improvement in conditions whereby previous work may become more available. Considerable space in the report is devoted to the examination of "duplicates," under the conviction that where true duplicates can not be obtained, "it is unwise to expend our energy in attempting work over which we can have no check. . . . Indeed, until agricultural science, so called, can be subjected to the tests that are recognized as essential to correctness in other sciences, we can not hope for that progress which we desire." The most important feature of the present report is the description and classification of the varieties of corn, which are graphically illustrated in the plates. The attempt at classification has been extended to the varieties of vegetables, of which some twelve hundred have been grown, "but the work is a difficult one, and requires much careful study." Other subjects embraced in the report are the trial of germinations, the rooting habits of plants, nitrogen-supply, feeding-experiments, and experiments with milk.

ITALIAN POPULAR TALES. By THOMAS FREDERICK CRANE, Professor of the Romance Languages in Cornell University. Boston and New York: Houghton, Mifflin, & Co. Pp. 389. Price, $2.50.

THE growing interest in the popular tales of Europe, and in the new branch of anthropological research, folk-lore, is the justification for the appearance of this handsome volume. By popular tales, the translator means the stories that are handed down by word of mouth from one generation to another of illiterate people, serving almost exclusively to amuse but seldom to instruct. They may be roughly divided into three classes: nursery tales, fairy stories, and jests. They were regarded with contempt by the learned till the brothers Grimm some sixty years ago collected those of Germany and introduced them to the public. Now they are industriously sought for and collected from all parts of the world. The stories in the present volume are, for the most part, presented for the first time to the English reader, and have been translated from recent Italian collections, which give them exactly as they were taken down from the mouths of the people. The stories are annotated for comment and illustration, and the subject is further elucidated by a history, in the introduction, of the principal Italian collections, and a bibliography.

TWO YEARS IN THE JUNGLE. By WILLIAM T. HORNADAY. New York: Charles Scribner's Sons. Pp. 512, with Map and Plates. Price, $4.

MR. HORNADAY is chief taxidermist in the United States National Museum, and was for several years collector for the natural science establishment of Professor Henry A. Ward, of Rochester, New York. The observations and adventures related in this book are such as happened to him while on a collecting tour for that gentleman, in the course of which he spent two years in India, Ceylon, the Malay Peninsula, and Borneo. That which he describes in it is offered as a faithful pen-picture "of what may be seen and done by almost any healthy young man in two years of ups and downs in the East Indies." The author says that he has labored in preparing his pages "to avoid all forms of exaggeration, and to represent everything with photographic accuracy as to facts and figures. It is easy to overestimate and color too highly, and I have fought hard to keep out of my story every elephant and monkey who had no right to a place in it. I consider it the highest duty of a traveler to avoid carelessness in the statement of facts. A narrative of a journey is not a novel, in which the writer may put down as seen anything that might have been seen."

JOURNAL OF THE AMERICAN AKADÊMÊ. ALEXANDER WILDER, Editor. Newark, New Jersey. Pp. 24.

THE American Akadêmê is an association having for its purpose to promote the

knowledge of philosophic truth, and to work for the elevation of the mind from the sphere of the sensuous life into that of virtue and justice, etc. Its members, it will be discerned, are to a large extent students of the Platonic philosophy. The most important paper in the present number is by J. B. Turner, and is on "Differentiation of Energy as the Basis of Philosophy and Religion." Mr. D. A. Wasson discusses the possibility of teaching virtue by verbal precept, with a decided inclination to the negative view.

A Political Crime. By A. M. Gibson. New York: William S. Gottsberger. Pp. 402.

This book is further entitled "The History of the Great Fraud," by which is meant the "counting in" of Hayes and Wheeler as President and Vice-President of the United States in 1876, when half of the American people believed that the candidates on the opposing ticket had been fairly elected. Its fundamental proposition, embodied in its opening sentence, is that Tilden and Hendricks were elected, and "were deprived of their choice by illegal methods, bolstered by frauds, perjuries, and forgeries." The author adds, "The surprising thing is that within less than a decade an almost complete revulsion in the opinions of the minority [the Republicans] should have taken place." Mr. Tilden's case is presented in full. The proceedings of the Returning Boards are narrated in detail, and conspiracy is freely charged against many of the men who figured prominently in the transactions relative to the election. As no election is now pending, the book can not be regarded as a campaign document; and the author is entitled to the presumption that his purpose in preparing it is to preserve what he regards as important facts and materials for history.

Something about Natural Gas: Its Advantages, Use, Supply, and Economies. By George H. Thurston. Pp. 32.

A pamphlet which applies more particularly to the natural gas of Tarentum, near Pittsburg, and which also sets forth the advantage of that place as a manufacturing center.

A Mortal Antipathy: First Opening of the New Portfolio. By Oliver Wendell Holmes. Boston: Houghton, Mifflin & Co. Pp. 307. Price, $1.50.

A new book by Dr. Holmes, redolent of his versatile genius and worthy of his fame. Happy are they who survive to enjoy this ripest product of the author's exquisite thought, for verily, this world has produced but one Dr. Holmes, and verily, verily, there will never be another, no matter how long it takes the solar system to run down! Great genius is never duplicated in the present economy of things, and the individuality of Dr. Holmes will forever stand alone in the history of creative literature. So let us all thank God for our good fortune in getting another of his charming and peerless books.

The contents of the new volume appeared as a serial in the "Atlantic Monthly" last year, under the title of "The New Portfolio." The scientific element which has been so striking and peculiar a characteristic of the former writings of Dr. Holmes here appears in the delineation of the career of a young man who, in infancy, had suffered a nervous disturbance so "sudden, overwhelming, unconquerable, appalling," from the carelessness of a pretty girl, that its effect remained in the system, so that afterward the sight of any young lady caused a repetition of the organic shock and deadly collapse. He was sent to a boys' school, and grew up to manhood the victim of this "mortal antipathy." The development of the story brings the young man, himself a physician of exquisite traits of mind and character, into such relations as, in the first place, to throw into a clear light all the physiological and medical aspects of the case, and then, with the most perfect art, the author relates the history of his restoration. The book is of absorbing interest, as well from its curious instructiveness as from the fascination of the story.

Milk Analysis and Infant Feeding. By Arthur W. Meigs, M. D. Philadelphia: P. Blakiston, Son & Co. Pp. 102. Price, $1.

Dr. Meigs publishes this little volume in the hope of contributing something toward the solution of the question of the composition of human milk, believing that, if some uniformity of opinion could be ar-

rived at on the subject, it would be a great step in advance toward the attainment of some positive conclusion in regard to the artificial feeding of infants. After a long and careful study of the matter, he is convinced that human milk contains much less casein than is commonly attributed to it; and he here puts forth his reasons, and a detail of the methods by which his conclusions have been attained.

A TEXT-BOOK OF MEDICAL CHEMISTRY. For Medical and Pharmaceutical Students and Practitioners. By ELIAS H. BARTLEY, M. D. Philadelphia: P. Blakiston, Son & Co. Pp. 376. Price, $2.50.

THIS book is designed especially as a text-book for medical students during their attendance upon lectures, and as a book of ready reference for physicians. The author, who finds the ordinary chemical text-books too voluminous and largely occupied with matter irrelevant to the wants of the medical student, has prepared in this one such a one as his experience of twelve years in the Long Island College Hospital, in which he is a professor, has taught him that his students need. In the first of the four parts into which the work is divided, are presented fundamental facts in chemical physics; in the second part, the elementary theories of chemistry; in the third part, the natural history of the elements and principal compounds, with their physiological and toxicological bearings; in the fourth part, those organic compounds only which the physician will be likely to meet. Tables and analyses are added for those who make the work a reference-book. The chemistry of the tissues and secretions is omitted, because it is considered to belong rather to physiological chemistry.

SAXE HOLME STORIES. First and Second Series. Pp. about 760. Paper. Price, 50 cents each series.

A WHEEL OF FIRE. By ARLO BATES. Pp. 382. Price, $1. New York: Charles Scribner's Sons.

THE "Saxe Holme Stories" attracted much interest when they were first published in "Scribner's Monthly," on account of their intrinsic merit, which was regarded as of the best, and of the mystery which was attached to their authorship. This was never revealed till a long time afterward. This interest has been renewed by the recent death of Mrs. "H. H." Jackson, and the avowal in connection with it that she was the author of the stories. They hold the first place among works of the class to which they belong. "A Wheel of Fire" is a tragic story of a young woman whose life was tormented by the apprehension of hereditary insanity, and all of whose plans and movements were controlled or modified by it.

BIRD-WAYS. By OLIVE THORNE MILLER. Boston and New York: Houghton, Mifflin & Co. Pp. 227. Price, $1.25.

A COLLECTION of sketches of the ways of certain birds which the author met in the fields or had as pets in her house, and of their moods and methods of expressing them. With the exception of a few incidents which are properly credited, everything recorded in the volume came, she says, under her own observation, and is literally and entirely true so far as the fact is concerned, although she may have sometimes misconstrued the motives of the little actors in the drama.

THE HEART, AND HOW TO TAKE CARE OF IT. By EDWIN M. HALE, M. D. New York: A. L. Chatterton Publishing Company. Pp. 94.

THE author has been moved to present a popular treatise on this subject by his conviction of the importance of the heart in the economy of the human organism, and by a belief that the public should know more about its functions, and the means of preventing or at least modifying the dangers to which it is exposed. His exposition is clear, practical, and unsensational.

PUBLICATIONS RECEIVED.

Report of the Committee on Disinfectants of the American Public Health Association. Baltimore. 1885. Pp. 187.

Fifth Annual Report of the State Mineralogist of California for the Year ending May 15, 1885. By Henry G. Hanks. Sacramento. 1885. Pp. 295.

Memorials of Henry Brace Norton. Pp. 110.

Revision of the Palæocrinoidea. By Charles Wachsmuth and Frank Springer. First Section. Philadelphia. 1885. Pp. 188, with Plates.

Hand-Book to the National Museum of the Smithsonian Institution, Washington. New York: Brentano Brothers. 1886. Pp. 110. Illustrated.

Photography of the Infra-red Region of the Solar Spectrum, 4 pages; and Methods of determining the Speeds of Photographic Exposures, etc., etc.,

14 pages, illustrated. By William H. Pickering. From Proceedings of the American Academy of Arts and Sciences.

A Plan for Ocean-Signals, Lightships, and Life-saving Stations, adapted for Coast and Deep-sea Service. By F. A. Cloudman. Rondout, N. Y. Pp. 15. Illustrated.

Digest of Laws governing the Issue of Municipal Bonds. Compiled by C. G. Neely. Chicago, Ill.: Published by S. A. Kean & Co., Bankers. Pp. 91.

Telescope Search for the Trans-Neptunian Planet. By David P. Todd, M. A. Lawrence Observatory, Amherst, Mass. Pp. 16.

The Inertia of the Eye and Brain. By James M. Cattell. London: William Clowes & Sons, Printers. 1885. Pp. 20.

Marsill's Almanac of Meteorology, for 1886. Rock Island, Ill. 1885. Pp. 44.

Joint Diseases: Treatment by Rest and Fixation, 15 pages; and Surgical Treatment of Infants, 12 pages. By Dr. De Forest Willard, of the University of Pennsylvania.

Annual Report of the Secretary of the Treasury for the Year 1885. Washington: Government Printing-Office. 1885. Pp. 114.

Bulletins of the United States National Museum. No. 28. Bibliographies of American Naturalists. II. The Published Writings of Isaac Lea, LL. D. By Newton Pratt Scudder. Pp. 337. No. 28. A Manual of American Land-Shells. By W. G. Binney. Pp. 528. Illustrated. No. 29. Results of Ornithological Explorations in the Commander Islands and Kamchatka. By Leonhard Stejneger. Pp. 381, with Plates. Washington: Government Printing-Office. 1885.

On Heating and Ventilation of Dwellings and School-rooms. By Charles O. Curtmon, M. D. Missouri Medical College. Pp. 10.

Reception-Day. No. 4. Recitations, etc., for Private and Public Schools. New York: E. L. Kellogg & Co. 1885. Pp. 156. 25 cents.

The Wherewithal, or New Discoveries in Cause and Effect. Philadelphia: Townsend. Wherewithal Publishing Company. 1885.

Report of Professor Spencer F. Baird, Secretary of the Smithsonian Institution, for Six Months ending June 30, 1885. Washington: Government Printing-Office. 1885. Pp. 46.

Notes on the Opium Habit. By A. P. Meylert, M. D. New York: G. P. Putnam's Sons. 1885. Pp. 49.

The City of Washington: Its Origin and Administration. By John Addison Porter. Johns Hopkins University Studies. Baltimore. 1885. Pp. 66. 50 cents.

The Genesis of Inventions. By Franklin A. Seely, A. M. Washington. 1885. Pp. 17.

Ericsson's Destroyer and Submarine Gun. By William H. Jaques. New York: G. P. Putnam's Sons. 1885. Pp. 48. 50 cents.

The Utilization of Culm in Agriculture. By J. A. Price. Scranton, Pa. 1885. Pp. 5.

The System of High Licenses. How it can be made successful. By G. Thomann. New York: The United States Brewers' Association. 1885. Pp. 36.

National Conference of State Boards of Health. Pp. 63.

Report of a Special Committee of the Franklin Institute, of Pennsylvania, on Competitive Tests of Dynamo-Electric Machines, and on Mechanical and Electrical Tests of Conducting Wires. Philadelphia. 1885. Pp. 65.

Gas-Engines. Report of the Examiner of Section XII, International Electrical Exhibition. Franklin Institute. Philadelphia. 1885. Pp. 11.

The Healing Art. Harveian Oration delivered before the Royal College of Physicians, October 19, 1885. By Richard Quain, M. D., F. R. S. London: Longmans, Green & Co. 1885. Pp. 44.

A Study of the Relative Poisonous Effects of Coal- and Water-Gas. By William T. Sedgwick and William Ripley Nichols. Pp. 41.

Contributions to Mineralogy. By F. A. Genth. University of Pennsylvania. 1885. Pp. 17.

Precious Stones. By George F. Kerry. Washington: Government Printing-Office. 1885. Pp. 62.

Diseases of the Perspiratory and Sebaceous Glands. By George H. Rohé, M. D. Baltimore. 1885. Pp. 62. 25 cents.

A Farmer's View of the Protective Tariff. By Isaac W. Griscom. Woodbury, N. J. 1885. Pp. 53. 35 cents.

The Geological Formation of Long Island, with a Description of its Old Water-Courses. By John Bryson. New York. 1885. Pp. 17.

Mineral Waters. By A. C. Peale. Washington: Government Printing-Office. 1885. Pp. 10.

The Columbia Bicycle Calendar for 1886. Boston, Mass.: Pope Manufacturing Company.

Thermometer Exposure. By Henry A. Hazen. Washington Signal-Office. 1885. Pp. 32.

Bulletins of the United States Geological Survey. No. 7. A Catalogue of Geological Maps relative to North and South America. No. 8. On Secondary Enlargements of Mineral Fragments of Certain Rocks. No. 9. A Report of Work done in the Washington Laboratory during the Fiscal Year 1883-'84. No. 10. On the Cambrian Faunas of North America. No. 11. On the Quaternary and Recent Mollusca of the Great Basin, with Descriptions of New Forms. No. 12. A Crystallographic Study of the Thinolite of Lake Lahontan. No. 13. Boundaries of the United States and of the Several States and Territories. No. 14. On the Physical Characteristics of the Iron Carburets, etc. Washington: Government Printing-Office. 1884 and 1885.

Bad Times. By Alfred Russel Wallace. London and New York: Macmillan & Co. Pp. 118. 75 cents.

The Iron Crown. A Tale of the Great Republic. Chicago: T. S. Denison. 1885. Pp. 560. $1.50.

Wonderful Escapes. Revised from the French of F. Barnard; and Original Chapters added by Richard Whiteing. 1885. Pp. 308. Illustrated. $1. Valentino. By William Waldorf Astor. 1885. $2. The Sun. By Amadée Guillemin. From the French by A. L. Phipson. 1885. Pp. 292. Illustrated. $1. The Greek Islands and Turkey after the War. By Henry M. Field, D. D. 1885. Pp. 228. Illustrated. $1.50. Wonders of European Art. By Louis Viardot. 1885. Pp. 335. Illustrated. $1. Strange Case of Dr. Jerkyll and Mr. Hyde. By Robert Louis Stevenson. 1886. Pp. 128. $1. Color Studies. By Thomas A. Janvier. 1885. Pp. 227. $1. New York: Published by Charles Scribner's Sons.

The Philosophy of Education. By T. Tate, F. R. A. S., with an Introduction by Edward E. Sheib, Ph. D. New York: E. L. Kellogg & Co. 1885. Pp. 331.

Social Wealth. By J. K. Ingalls. New York: The "Truth Seeker" Company. 1885. Pp. 320. $1.

A Hand-Book of Whist. By Major Tenace. 1885. Pp. 110. 75 cents. The Industrial Situation and the Question of Wages. By J. Schoenhof. 1885. Pp. 157. Brain-Rest. By J. Leonard Corning, M. D. 1885. Pp. 135. $1. New York: G. P. Putnam's Sons, Publishers.

Applied Geology. By Samuel G. Williams. 1886. Pp. 386. $1.40. Ecclesiastical Institutions. By Herbert Spencer. 1886. Pp. 182. $1.25. Anthropoid Apes. By Robert Hartmann. 1886. Pp. 326. $1.75. New York: D. Appleton & Co., Publishers.

Japanese Homes and their Surroundings. By Edward S. Morse. With Illustrations by the Author. Boston: Ticknor & Co. 1886. Pp. 372. $3.

Third Annual Report of the Bureau of Ethnology, 1881-'82. By J. W. Powell, Director. Washington: Government Printing-Office. 1884. Pp. 606.

The Annals of the Cakchiquels. The Original Text with a Translation, Notes, and Introduction. By Daniel G. Brinton, A. M., M. D. Philadelphia. 1885. Pp. 234.

POPULAR MISCELLANY.

Employés and Employers.—The Lehigh Valley Railroad Company has established a relief fund into which the employés put voluntary contributions, and for every dollar put in by a person in its employ the company puts in another dollar. Thus, if the 14,000 employés contribute a dollar each, the company will contribute $14,000. The management of the fund is in the hands of President Wilbur and Paymaster Wilhelm. In case a contributor is disabled by accident, he is allowed three fourths as much per day as his contribution in the fund every working-day during his disability, for a period of six months. In case the accident results in the death of the contributor within six months, or if he is instantly killed, $50 is appropriated from the fund for the funeral expenses. If he leaves a widow and children under sixteen years of age, an allowance of one half the amount of his contribution, for every working-day, is appropriated and paid the widow for one year from the time of the contributor's death, provided she remains unmarried during that time. If there be no widow, then the allowance goes to the children, if any, for the same period. In case the contributor loses a limb, he is provided with an artificial limb, and employment is given to him. —*Railway Review.*

Vapor- and Hot-Air Baths.—The value of hot-air and vapor baths, as well as of other means of promoting the perspiratory function of the skin, has been recognized from very ancient times; and nearly all peoples are acquainted with some means of producing the desired effect. The modes of taking these baths are exceedingly various. Among them are the Turkish and Russian baths, which are, however, usually arranged on too large a scale to be regarded as practicable for small households. Of hot-air baths, the extemporized "rum-sweat" is among the most common. The naked person is seated in a chair, enveloped in blankets which, spread over the chair, inclose him as in a kind of tent extending from his neck to the floor. The heat is supplied by burning spirit contained in a small earthen vessel, which is slipped underneath the chair. This method is attended with considerable peril, the reality of which has very recently been forcibly brought to mind by the death of Dr. W. B. Carpenter, who, taking a hot-air bath in almost precisely this way—using a gallipot of burning spirit instead of his bath-lamp, which was out of order—upset the vessel in changing position, and was so severely burned by the ignited vapors that he died in about four hours afterward. One of the simplest forms of vapor-bath was the old "hemlock-sweat," which, while it was a rude and far from convenient application, was efficacious, and had the character of a medicated bath. Hemlock-boughs, with the leaves, were broken up into a pail, and hot water was poured upon them, with the effect of immediately "steaming" the hemlock. The pail was then slipped under the blankets with which the bather was invested, while simultaneously a red-hot brick was dropped into it, whereby the bather was immediately involved in a profusion of aromatic steam, as hot as he could comfortably endure. We remember to have seen, many years ago, a simple, cheap, and tolerably convenient portable vapor-bath, in the shape of a chair constructed especially for the purpose, with provisions for burning alcohol with reasonable safety and producing steam, all contained within itself. The safest and most convenient arrangement which has come under our notice is the "Home Vapor-Bath," which was invented by Mr. William W. Rosenfeld, it is said, when he was only sixteen years of age. It is compact, and can be introduced, at small expense, into any house having "hot-water" attachments. It is applied to the ordinary bath-tub as it is found in nearly every good house, and, depending wholly upon the use of the hot-water pipe of the tub, avoids the direct application of fire. It can be used with any bath-tub, in addition to the other and usual arrangements, and without disturbing any of them. The principle of its operation consists in subdividing the hot water into small jets over a large area, so as to allow the maximum of evaporation. This is ac-

complished by affixing to one side of the tub a perforated shower-tube connected with the hot and cold water supplies. The bather sits upon a chair at the foot of the tub, enveloped in a curtain of rubber cloth, with an attachment extending over the tub. He is thus assured the full benefit of all the evaporation from the hot water, while his face is totally shut off from it, so that he does not breathe any of it. By means of another equally simple attachment, substances with which it may be desired to medicate the bath are brought into contact with the water and made to mingle their fumes with the steam. This form of bath, which has all the advantages of the Russian bath, and is, moreover, adapted to domestic use, has been introduced into a great many houses in New York and other places, as well as into hotels and public institutions, and is highly recommended by those who have employed it or examined it. In another form of apparatus, sold by J. Allen & Sons, of London, the lamp is placed outside of the curtain, within which the vapor is conducted by a pipe. The whole apparatus can be packed into a box less than twelve inches square. An arrangement is also furnished by which the vapors are introduced into the bed in which a patient may be lying; or the lamp, if preferred, may be put directly under the chair. This bath has received medals and high awards at several "health" or "sanitary" exhibitions.

A Sun-heating Apparatus for Rooms.—Professor Edward S. Morse, of Salem, Massachusetts, has tried the experiment of calling in the heat of the sun to assist in warming and ventilating his house. He attaches to the wall of his house a box nearly the height of the story, about three feet wide, and of suitable depth, and so arranged and connected with openings in the wall as to act as a flue. The outside of the box is made of slate or black corrugated iron, substances which absorb heat, and over this is a "window" of glass. With this apparatus, the air in a room measuring twenty-one by thirteen by nine feet, could be changed in forty-five or fifty minutes, and a very perceptible degree of warmth was obtained. A similar heater, forty-two feet long and six and a half feet wide, attached to the Boston Athenæum, is estimated to do work that would ordinarily require between twenty-five and fifty pounds of coal a day.

Earthquake-proof Buildings.—The committee of the British Association appointed to investigate the earthquake phenomena of Japan, after reporting upon their experiments into the nature of the vibrations of the ground, offer some suggestions on the construction of earthquake-proof houses. In a house resting at its foundations on cast-iron balls, the measuring instrument showed that, although considerable movement took place at the time of an earthquake, all sudden motion had been destroyed; but wind and other causes produced movements of a far more serious character than the earthquake. To give greater steadiness to the house, eight-inch balls were tried, and then one-inch balls. Finally the house was rested, at each of its piers, upon a handful of cast-iron shot, each one fourth of an inch in diameter. By this means the building has been made astatic, and, in consequence of the greater increase in rolling-friction, sufficiently stable to resist all effects like those of wind. The shot rest between flat iron plates. When erecting a building in a region subject to earthquakes, it appears that we ought first to reduce, as far as possible, the quantity of motion which ordinary buildings receive; and, second, to construct a building so that it will resist that portion of the momentum which we are unable to keep out. To reduce the momentum we may—1. Select a site where experiment shows that the motion is relatively small. 2. For heavy buildings, adopt deep foundations (perhaps with lateral freedom), or, at least, let the building be founded on the hardest and most solid ground. 3. For light buildings, put in the shot foundations. As against the momentum which can not be cut off from the building, it should be borne in mind that it is chiefly stresses and strains which are applied horizontally to a building that have to be encountered. A vertical line of openings, as in doors and windows in a building, constitutes a vertical line of weakness to horizontally applied forces. Avoid coupling together two portions of a building which have two vibrational periods, or which, from their position, are not

likely to synchronize in their motion. If such parts of a building must of necessity be joined, let them be so joined that the connecting link will force them to vibrate as a whole, and yet resist fracture. Brick chimneys in contact with the framing of a wooden roof are apt to be shorn off at the point where they pass through the roof. Light archways connecting heavy piers will be cracked at the crown. To obviate destruction from these causes, a system of building may be adopted which essentially consists of tying the building together at each floor with iron and steel tie-rods, crossing each other from back to front and from side to side. The center of inertia of a building, and of its parts, should be kept as low as possible. Heavy tops to chimneys, heavy copings, and balustrades on walls and towers, heavy roofs and the like, are all of serious danger to the portion of the structure by which they are supported. When the lower part of a building is moved, the upper part, by its inertia, tends to remain behind, and serious fractures often result.

Poteline.—The plastic substance, poteline, introduced by M. Potel, is formed of a mixture of gelatine, glycerine, and tannin, to which may be added sulphate of baryta or zinc-white; and the whole may be colored, if desired, with vegetable colors. Poteline is molded while still hot; and, when it has become cool, yields itself to every kind of manipulation. It can be turned, filed, bored, or screwed, and it is susceptible of a very fine polish, which may be conveyed by pressure. This facility of working permits it to be treated in the same way as bronze, and makes it adaptable for all kinds of mountings. It can also be used to seal bottles and jars hermetically, for the fabrication of dolls' heads that can not be broken, and for the composition of an artificial marble out of which ink-stands, door-knobs, and a thousand other articles can be made cheaply. The proportion of the different materials entering into the composition of this substance varies according to the use that is to be made of it. For sealing bottles, it should be used in a nearly liquid condition; for the manufacture of fancy articles, in an opaque form; while the exact composition of the marble-poteline is a secret known only to the inventor. M. Potel has described a method by which he uses poteline as an envelope, to stop and prevent fermentation and insure the preservation of fruits and meats.

Oyster-Culture in Connecticut.—According to the last report of the Shell-fish Commissioners of the State of Connecticut, the policy of farming out the oyster-grounds to individual proprietor-cultivators has been very successful. The number of persons engaged in the business increased ten per cent during the seven months covered by the report; and the rapid development of the oyster industry is further shown in the continued extension of the area of grounds devoted to it, and in the increase in the number of oyster-steamers. It has been found that with reasonable care and labor the number of star-fish may be so reduced that those enemies shall be incapable of doing serious damage to the oyster-beds. A new enemy, however, threatens the beds, in the shape of a sand-tube-building worm, whose structures cause accumulations that suffocate the oysters; but the estimates are contradictory as to the amount of the damage it is likely to do. Efforts have been made during the past year, with much success, to redeem muddy grounds and make them available for oyster-cultivation by covering them with shells and pebbles brought from the Housatonic River. The demand, both for oysters and for seed-oysters, is constantly increasing, and it is not likely that the supply will soon go ahead of it.

What is a Real Forest?—In all forest-culture, says Mr. M. C. Read, in a paper on "The Preservation of Forests on the Head-Waters of Streams," which is published by the Department of Agriculture in "Special Report No. 5," "it should be remembered that, for climatic purposes, an orchard of trees is not a forest. The planting of trees along the highways, about our homes, in parks and groves, ought to be encouraged for a variety of reasons, but will have little of the climatic effect of true forests. A dense growth of underbrush, herbaceous plants, and mosses under the larger trees, which will retain the fallen leaves in place, fill the surface-soil with rootlets, checking

the flow of water and facilitating its entrance into the earth, is an essential part of a true forest."

Popularizing Agricultural Colleges.—In the Convention of Delegates from Agricultural Colleges and Experiment Stations, which was held at the Department of Agriculture in July, 1885, the question was considered how the colleges can be made more directly useful and more in sympathy with the people. President Fairchild, of the Kansas State Agricultural College, said that the Michigan College had arranged in 1875–'76 for a series of farmers' institutes to be held each winter in the different counties of the State. At each institute, the college undertook to provide only half of the programme, and insisted that the place where the meeting was held should provide the other half. The expenses of the institute were also divided equitably. Every question brought forward was open to discussion, to which close attention was given, and which was always encouraged. From that day to this, the institute has grown in favor with both the farmers and the professors in the Agricultural College. "The same thing," Mr. Fairchild added, "has been in vogue with us in Kansas since I went there in 1879. We opened a series of institutes in the winter of 1880–'81, and have continued them from that day to this, with growing interest, and with especial favor as regards the farmer. We promote discussion upon just such questions as the farmers wish discussed, and the professors take especial pains to meet the questions which may be raised by the farmers themselves." The people are thus brought into full fellowship, which they demonstrate, with the college; and in Michigan the reports of the State Board of Agriculture, which formerly had to be "thrown at the heads of politicians," are in demand and are read.

More about the Effects of Tobacco.—Dr. Hobart Amory Hare, of the University of Pennsylvania, after an elaborate dissertation on "The Physiological and Pathological Properties of Tobacco," expresses the conclusions that "tobacco does no harm when used in moderation—to the man who, by occupation, leads an out door life, or one in which much physical exercise is taken, but rather does good, by quieting any tendency to continued action which may exist; to those who, by exceptionally long use, have become inured to the effects of the drug, and whose systems depend upon it; or to those whose temperaments are naturally phlegmatic and easy-going. Tobacco does harm to the young and not yet full-grown; to the man of sedentary habits; to the nervous and those whose temperaments are easily excited; and to the sickly and those who, by idiosyncrasy, are strongly affected by the drug." The different methods of using tobacco are harmful in the following order: Chewing, cigarette smoking, cigar smoking, pipe smoking, Turkish-pipe smoking. The quality of the drug governs the degree of its harmfulness more stringently in some cases than in others, as do also the character and constituents of the paper in which cigarettes are wrapped. Finally, the oft-repeated words "excess" and "moderation" "form the key-stones of the arches which the writers on tobacco, *pro* and *con*, have raised."

Life in New Guinea.—The Rev. J. Chalmers, a missionary, recently visited the country west of Maclatchie Point, Southeastern New Guinea. He found the people generous and hospitable. They are certainly cannibals, but only as concerns their enemies. Sorcery and superstition have their home among them. In a *dubu*, or sacred house, which Mr. Chalmers describes as the finest he has ever seen, two large posts, eighty feet high, support a large peaked portico, thirty feet wide, while the whole building is one hundred and sixty feet long, and tapers down in height from the front. A large number of skulls of men, crocodiles, cassowaries, and pigs ornament it. The human skulls are those of victims who have been killed and eaten by the tribe; and they speak of this kind of food as the greatest luxury, and think those are fools who despise it. The whole district from Orokolo to Panaroa is one great swamp, and the villages are all surrounded by muddy water. Canoes are a necessity in making morning calls. Bridges of logs or trunks form the streets, and the roads are more easily traversed barefoot than in boots. The houses

are really well built, and in front of many of them are small gardens, raised ten feet from the ground. To make these gardens, a well-built platform is covered with soil, in which flowers and tobacco are planted and cultivated.

The International Geological Congress.—The International Geological Congress held its sessions in Berlin from the 28th of September to the 4th of October last, and was attended by two hundred delegates of various nationalities, among whom were Mr. McGee, Professor Newberry, and Professor James Hall, from the United States. The German geologist, Von Dechen, who is eighty-five years old, was named honorary president, while Professor Beyrich served as effective president. Among the important matters to receive attention was the report of progress upon the geological map of Europe, the execution of which had been put in charge of a special commission by the preceding Congress at Bologna. The choice of colors made at Bologna was pronounced a happy one; and the principle of marking the subdivisions of periods by graduated tints of the same color, the darker tints indicating the older beds, was approved. The report on nomenclature stated that, while the Congress of Bologna had established the fundamental principles on the subject, there were some important matters which it had not settled, and upon which the international committees had not been able to agree. On the points considered in this report the Congress decided that the Triassic and Jurassic formations should be divided into three series each, and the Cretaceous into two, the lower series including the Gault. On other points, on which differences of opinion were more pronounced, discussion was remanded to special publications and to future consideration. Professor Neumayr, of Vienna, asked the sanction of the Congress to his contemplated "Nomenclator Palæontologicus," to be published in fifteen volumes of a hundred pages each, in which should be given the names of all vegetable and animal fossils, with the beds in which they occur and the works in which they are described. It will have a French introduction and a Latin text, as brief as possible. The next meeting of the Congress was appointed to be held in London in 1888, between the 15th of August and the 15th of September.

The New England Meteorological Society.—At the annual meeting of the New England Meteorological Society, held in Boston, October 20th, Professor Davis read a paper upon the thunder-storms of the summer of 1885, and Mr. Harold Whiting a paper on the self-recording aneroid barometer. A full presentation of the year's work of the society was given in the report of the Council. The number of members had increased from nine in November, 1883, to ninety-five; the number of observers sending reports from forty-five to one hundred and twenty-three. Efforts had been constantly made to secure increased accuracy and greater uniformity in the observations. The subject of accurate instruments received early attention; and it was decided to manufacture a special class of rain-gauges rather than to adopt any now in the market, and to adopt certain makes of self-registering thermometers. All desiring to make observations have been encouraged to do so, and efforts have also been made to secure observers in special localities. In co-operation with the United States Signal-Service, local weather-flags are daily displayed in more than a hundred cities and towns of New England. More than four hundred observers have co-operated in the special investigation of thunder-storms; and two hundred and three reports were sent in of a single storm. The National Academy aids these investigations with an appropriation of two hundred dollars. The expenses of the society have, by the aid of friends, been kept within its income. As its financial prosperity depends on the number of members, it is desired to include in the membership all who are interested in meteorological studies in New England, whether they make observations or not.

How to exalt the Teacher's Art.—"Teaching as a Business"—that is, why is it not a profession?—is the title of a paper which was read by C. W. Bardeen before the National Educational Association at its last meeting. One reason why teaching is not a profession lies in the way school

boards are made up; another, in the fact that so large a proportion of incompetents are applying for positions, not forgetting the highest ones. It is not strange that, with such persons obtruding themselves, the teacher is looked upon by such boards as we have as "an impracticable man, useful enough to take care of boys and girls under rules established by lawyers, doctors, and business-men, but unfitted for participation in any of the serious work of the community." Mr. Bardeen, in looking for a remedy for the low state of the business, holds that it should not be thought to depend upon higher salaries or pensions for retired teachers, or fixed tenure of office—the teacher, if matters were in a proper condition, should be no more anxious about his annual reappointment than the bank-teller or insurance president, who is sure of it so long as he is this side of the St. Lawrence! But teachers should discriminate among themselves in favor of the most competent, should be men among men, should see to it that the differences in the results of good teaching and poor teaching are proved, and emphasized, and illustrated, and should labor to have the work of superior teachers recognized and secured. The average school board is a checker-board, where the only important consideration is that the square be covered, with a button, if the real piece is not at hand; it should be like a chess-board, where, "when a knight falls to the carpet, you do not replace him by a pawn, a rook, or a bishop; and you will make almost any sacrifice to retain your queen. One of these pawns may sometimes be a queen, but not till by long probation and many steps of progress it has won its position in the queen's row. There should be a queen's row in teaching."

The Value of the Congo.—A letter from Mr. Stanley, protesting against giving up the control of the Congo to the Portuguese, which was read in the Geographical Section of the British Association, gives a magnificent idea of the value of what that river is capable of contributing to the advance of civilization. "Despite every prognostication to the contrary," says Mr. Stanley, "this river will yet redeem the lost continent. By itself it forms a sufficient prospect; but, when you consider its magnificent tributaries which flow on each side, giving access to civilization to what seemed hopelessly impenetrable a few years ago, the reality of the general utility and benefit to these dark tribes fills the sense with admiration. Every step I take increases my enthusiasm for my work and confirms my first impressions. Give 1,000 miles to the main channel, 300 to the Kwango, 120 to Lake Matenba, 300 to the Mobimbu, probably 800 to the Kaissai, 300 to the Saukuru, 500 to the Aruwimi, and 1,000 more to undiscovered degrees, for there is abundant space to concede so much, and you have 4,520 miles of navigable water."

A New Zealand Ice-Cave.—The Whaugachu River, of New Zealand, rises in an immense, deep, perpendicular walled ravine on the slopes of Mount Ruapehu, in which its descent is varied by a succession of waterfalls—"Horseshoe," "Bridal-Veil," etc., varying from 150 to 400 feet in height. "At one point, where the scene is hemmed in with towering precipices of 1,000 feet high and a glacier-slope in front, the gorge," says Mr. Nicholls, "wound in such a way that none of the surrounding country could be seen, and there was nothing but the blue heavens above to relieve the frigid glare of the ice, the cold glitter of the snow, and the dreary tints of the frowning, fire-scorched rocks. Right under the snowy glacier above us were wide-yawning apertures, arched at the top, and framed as it were with ice in the form of rude portals, through which the waters of the river burst in a continuous stream. We entered the largest of these singular structures, and found ourselves in a cave of some 200 feet in circumference, whose sides of black volcanic rock were sheeted with ice and festooned with icicles. At the farther end was a wide cavernous opening, so dark that the waters of the river, as they burst out of it in a foaming, eddying stream down the center of the cave, looked doubly white in comparison with the black void out of which they came. The roof of the cave was formed of a mass of frozen snow, fashioned into oval-shaped depressions, all of one uniform size, and so beautifully and mathematically precise in outline as to resemble the quaint designs of

a Moorish temple; while, from the central points to which the edges of these singular designs converged, a long single icicle hung down, several inches in diameter at its base, perfectly round, smooth, and as clear as crystal, tapering off toward its end with a point as sharp as a needle." Wherever the water poured over the rocks it left a white deposit, which, when tasted, produced a marked astringent feeling upon the tongue, with a strong impression of alum, sulphur, and iron.

Malaria-Factories in Mauritius.—Reference having been made in a recent health-lecture at the Society of Arts to an outbreak—the first in the history of the island—of malarial fever which occurred in Mauritius in 1866, Mr. F. Guthrie, who was there at the time, gives a statement of what he found, upon examination, was the cause of the outbreak. The embankments of the new railroad had caused the accumulation of water in ponds on either side of the track. This became stagnant and impregnated with the sewage that surged down from the higher land, till it was strongly offensive to the sight and the smell. In view of the existence of these cess-pools on a grand scale, Mr. Guthrie does not believe that the outbreak was due to the "clearing of the forests" or to the "upturning of the virgin soil," but simply "to the infatuation of those who did not know, and who, even when it was pointed out to them, could not see that, when lagoons of sewage and salt-water are reeking beneath a semi-tropical sun, fever is the rule rather than the exception."

Dancing as Physical Training.—Dr. Crichton Browne has had a good word to say for dancing. In a recent lecture before the Birmingham (England) Teachers' Association, he insisted on the importance of a timely training and discipline of all motor centers, so that advantage may be taken of the superior plasticity that characterizes them during their period of growth. He spoke of the value of the educational training in this way of the hand-centers of to-be artisans, of the different kinds of muscle-work, and in regard to dancing said that, if taught at the proper time—that is, very early in life—it "may discipline large groups of centers into harmonious action, enlarge the dominion of the will, abolish unseemly muscular tricks and antics, develop the sense of equilibrium, and impart grace and self-confidence. Every day," he continued, "we may detect in the conversation or carriage of persons we meet painful evidences of the neglect of dancing and deportment in the rearing of the young."

Mechanical Repetition and Intellectual Knowledge.—It has sometimes been observed that, when children of savages are put to school, they exhibit great readiness, and sometimes precocity, in learning the elementary branches till they reach a certain age, when they all at once fall off. Professor W. Mattieu Williams regards this as a sign of their intellectual inferiority, and a consequence of it. The earlier instruction of these children "mainly consists in 'learning lessons,' mechanical practice in writing, and mechanical use of the rote-learned addition and multiplication tables. So far, mere verbal memory, finger-moving, and repetition-gabble of numbers, does all the work. The higher intelligence of the child contributes little or no aid in the performance of such tasks; it rather stands in the way by inducing thought, i. e., distracting the child's attention from the mechanical drudgery demanded. When work demanding thought is required, whether it be higher school-work or the business of practical life, the difference between the Caucasian and the lower races comes out; not because there is an arrest of development in the lower, but because the higher demand displays the working of the higher faculties. A glib aptitude for learning foreign languages is, generally speaking, an indication of intellectual inferiority, a simple result of the lower intellectual faculties being concentrated upon such mechanical effort without the distracting influence of the higher reasoning powers."

M. de Mortillet on Tertiary Man.—M. G. de Mortillet read a paper before the Anthropological Section of the French Association on Tertiary "man," in which he said the question was not one of knowing whether man existed in the Tertiary epoch as he ex-

ists to-day. Animals have varied from one geological stratum to another, and the higher the animals, the greater has been the variation. It is to be inferred, therefore, that man has varied more than the other mammals. The problem is to discover in the Tertiary period an ancestral form of man, a predecessor of the man of historical times. There are in the Tertiary strata objects which imply the existence in that age of an intelligent being; and such objects have been found in two different stages of the epoch —in the Lower Tertiary at Thenay, and in the Upper Tertiary at Otta, in Portugal, and at Puy Courny, in Cantal. They prove that at those two distant epochs there existed in Europe animals acquainted with fire, and able, more or less, to cut stone. During the Tertiary period, then, there lived animals less intelligent than existing man, but more intelligent than existing apes, although their skeletons have not yet been discovered, only their works. To these species, the ancestral forms of historic man, M. de Mortillet would give the name of anthropopithecus, or man-ape.

Words and Things.—A writer in the "Journal of Science" remarks upon the inadequacy of language to describe motions, as in the flight of different species of butterflies; colors, except a few particularly named ones; forms, except geometrical ones; and tastes and odors, in which the failure is complete. At the same time our mental conceptions of all these things may be of the clearest, when they have once passed under observation. To this he appends the pertinent question: Seeing how very impotent is language, unaided, to convey precise knowledge, "Why is such exclusive attention paid to words, both in lower and higher education, to the almost entire neglect of things? Verbal memory is cultivated above all other faculties of the human mind. Much care is taken to train up youth in the correct use of language. But in what school is the art of observation systematically taught? Who heeds or asks whether the observing faculties are strengthened? Quite the contrary; these faculties, if perhaps not intentionally, are not the less weakened and crowded out by dominant verbalism. . . . I am not seeking to undervalue the use and study of language. It furnishes, at any rate, receptacles in which the rough outlines of our knowledge may be preserved. But it must no longer seek to maintain the exclusive position which it has usurped. It must be made to feel that it is the espalier and not the vine, the purse and not the money, the shell and not the substance."

Sands of the Turkistan Deserts.—According to an account by M. Paul Lessar, of the Russian Geographical Society, the sands of the Kara-Kum Desert of Turkistan, represented on maps by one conventional sign, are in reality very varied, and are divisible into three principal kinds. In the country between Merv and Attok, and between Sarakhs and Chacha, the soil is clayey, largely mixed with sand; its surface is formed into hillocks, rarely more than seven feet high, and usually thickly overgrown with brushwood. This kind of desert presents no particular obstacles to the traveler. The second kind of desert consists of real sands—not, however, of a drifting nature, but everywhere knit together by bushes ten or fifteen feet high. It is only at the summits of the hillocks, which are higher than those just described, that there is a little drift-sand, which is carried from place to place. In sands of this kind, carts move with great difficulty, while horses and camels go freely. No storm need be dreaded in these deserts, for the quantity of drift-sands is so small that it can not become dangerous, though it may cause considerable discomfort. The case is, however, very different with the sands of the third kind, or the so-called *barkhans*. In them no tree or bush or grass-blade is to be seen; the sand is wholly of a drifting nature; and the slightest puff of wind effaces the fresh tracks of a caravan. Wherever they meet a bush they are deposited around it by the wind in hillocks that assume a variety of shapes. When the hillocks have covered the bushes they are molded by the wind according to one pattern, in which the side exposed to the wind presents a gradually raised cone, and the reverse a sharp curve, while a section might be accurately figured by a rib. The passage of these sands is very difficult. Horses sink and are hardly able to extricate their

feet. It is necessary to proceed with the utmost caution in order not to lose one's way; for there is nothing to serve as a sign-post, except occasional sticks placed by passing caravans; and the wind blows them down and the sand covers them. Each successive caravan replaces them in the most convenient spot. These sticks have to be followed on the march, for, when the least wind is blowing, only the most skillful and experienced guides can trace the direction of the road. The *barkhans* shift from place to place; and plain evidence of their drifting nature appears before the eyes of every traveler between Merv and Bokhara. When they move, it is usually without undergoing any change of shape. Besides the sands in the Kara-Kum, M. Lessar describes the *kyrs*, *takirs*, and *shors*. The *kyrs* are firm surfaces of clay mixed with sand, only occasionally covered with sand-hillocks, and hardened by vegetation. They usually consist of a row of valleys alternating with eminences not exceeding from one hundred and forty to two hundred and ten feet in height, and are always passable. The *takir* is a very hard surface devoid of vegetation, surrounded on all sides by sands almost horizontal or sloping but slightly. The clayey soil is impervious to water, but presents a very slippery surface in rainy weather. *Shors* are similar in appearance to *takirs*, but distinguished from them by their soil, which is a ferruginous sand, with gypsum protruding in many places on the surface. They are sometimes dry and sometimes boggy; but in any case not difficult of passage.

Ancient Anæsthetics.—A recently discovered manuscript by Abélard gives some curious information concerning the means employed by the surgeons of his time to produce insensibility during their operations. Pliny mentions a stone of Memphis which, brayed and applied with vinegar, was put on particular parts of the body to anæsthetize them. He, Dioscorides, and Mattheolus speak of putting patients to sleep previous to operations by causing them to take, in bread or some other food, the juice of the leaves or a decoction of the roots of mandragora, or a dose of the plant called morion. Opium and hemp were used by the Chinese In the poly-composite pharmacy of the thirteenth century a preparation was made of opium, the juices of henbane, mandragora, hemlock, and other plants, with which sponges were charged. Having been dried in the sun, the sponges were moistened when it was desired to use them, and then applied under the noses of the patients as chloroform sponges are now applied.

A Chinese Dinner in High Life.—A member of a Bremen trading-house lately had the honor of taking dinner with a Chinese magnate in Pekin, and has given an appetizing description of the feast. The table was set with twenty-two dishes, and was lit with ten large lanterns, the light of which shone clear through brightly colored shades and ornaments. Instead of being served in courses, the dishes were brought in one at a time and passed to the guests severally, beginning with the most distinguished or with the oldest. The merchant has given a list of them, with his comments, as follows: 1. Doves with mushrooms and split bamboo-sprouts—delicious. 2. Fat-pork fritters (or something like fritters)—splendid. 3. Pigeon's-eggs in meat-broth, the whites hard but transparent—very good. 4. Chinese bird's-nests with ham-chips and bamboo-sprouts (a mucilaginous dish)—excellent. 5. Poultry, different kinds, cooked with mushrooms and bamboo-sprouts—very agreeable. 6. Duck, with bamboo and lotus fruits, the fruits tasting and looking like an acorn without its cup—tolerably good. 7. Hog's liver fried in castor-oil—bad. 8. A Japanese dish of mussels with malodorous codfish and bacon—horrible. 9. Sea-crabs' tails cooked in castor-oil, with bits of bamboo and ham—would have been palatable but for the wretched oil. 10. A star made of pieces of fowl, bacon, and dove, covered with white of egg—very juicy. 11. Slices of sea-fish and shark's fins, with bamboo and mushrooms—it was hard to tell what kind of a dish it was, but it was rather bad than good. 12. Giblets of poultry with morels—the morels helped the giblets down. 13. Ham and cabbage—not particularly good. 14. Hams of sucking pigs cooked in their own juice. A pause now ensued, during which pipes and tobacco were brought in. The pipes held about a

thimbleful of tobacco—enough for two or three whiffs—and we were kept busy filling and lighting them. 15. Land-turtles with their eggs in castor-oil—abominable. 16. Ends of ham—good. 17. Breast of fowl with sour cabbage—no delicacy. 18. Stale eggs (these eggs had been kept one month in salt and two months in moist earth). The whites looked like burned sugar, and were transparent. The yolks had a greenish color, and the embryos appeared dark, rolled together, and perfectly recognizable—a terrible dish. Dessert: Conserve of sitzon, a red fruit that looks like a shadberry, and tastes like a kind of currant—good. Dark-green fruits, having oval seeds like those of the plum, preserved in brandy—good. Crabs' tails cooked in castor-oil. A green, oval fruit with a long, hard seed, resembling a large green olive, but sharp and sour, and disagreeable to the European taste. Light cakes—very fine. Nuts, almonds, and castor-oil seeds, roasted and candied with sugar—good, even to the castor-oil seeds. Macaroni with sesame-seeds and three-cornered cakes covered with castor-oil seeds—passable. Various bonbons very moderate; baked lichis. The lichi is the finest of Chinese fruits, having a white flesh with the taste of the best grapes—excellent. Shaddocks and mandarin oranges—good. The only drinks were tea, very weak and without sugar, and samion, a rice-wine, which is drunk hot like tea, and is wretched stuff.

Temperature of Germination.—M. Hellriegel has undertaken, in a series of experiments on eighteen species of cultivated plants, to ascertain the lowest temperature at which seeds are capable of germinating. The seeds, sprinkled with distilled water, were planted in large receptacles filled with vegetable mold that were raised to constant temperatures of 48°, 40°, 38°, 35°, and 32°, and kept there from thirty-five to sixty hours. It was found that rye and winter wheat germinated at 32°. Barley and oats showed their cotyledons at 32°, but did not start till 35° were reached. Indian corn required 48°. The turnip germinated at 32°, flax at 35°, the pea and clover at 35°, the bean and lupin at 38°, asparagus at 35°, the carrot at 38°, and the beet at 40°. The respiratory function requires little heat, and operates even in the entire absence of light. Heat and light are, however, most favorable for the assimilation of carbonic acid and its conversion into carbon. But little importance is attached to the color of the light.

Dust in Rooms.—Professor W. Mattieu Williams contends that minute particles of dust are repelled or driven away from heated bodies, and that the repulsion operates in the open air and confined spaces alike. Large bodies, he adds, are similarly repelled, but as the repulsion acts only superficially and the inertia of a mass of given matter increases with the cube of its through dimension, and its surface only with the square of the same, the repulsion of such masses demands special and delicate arrangements to render it visible. Assuming this view—that dust is repelled from warmer to cooler bodies, be those bodies solid or gaseous—to be proved, then, "if the walls, floor, ceiling, and furniture of a room be warmer than the air of the room, the dust will be repelled from the walls, etc., to the air; while if the air be warmer than the walls the dust will be projected from the air to the walls." Hence those methods of warming rooms are to be preferred which heat the air rather than the solid objects; and this, in Mr. Williams's opinion, should exclude open fires.

NOTES.

THE committee of the American Association on Indexing Chemical Literature, at the last meeting of the Association reported progress, by Professor William R. Nichols, on carbon monoxides; Professor L. P. Kennicutt, on meteorites; and Professor C. E. Monroe, on explosives. Dr. H. C. Bolton has published a catalogue of chemical periodicals, and Hans Wilder, independently of the Association, a list of nearly nine hundred chemical tests known by the names of their authors. Dr. Bolton's second index of the literature of uranium has been accepted. Dr. F. E. Engelhardt has offered to undertake an index to the literature of common salt. The committee's report presents a scheme for indexing scientific literature, in both author and subject indexes, prepared by Professor William Frear.

M. DEMARÇAY, by means of an induction-coil made of comparatively large and

short wire, obtains a spark, without having to employ strong currents, which is of sufficiently high temperature to give the spectra of all the known elements. Atmospheric lines of the second order are not obtained with it, and the nebulous bands of nitrogen and the lines of the electrodes only rarely.

Dr. Daniel G. Brinton, of Philadelphia, has been announced a laureate of the Société Américaine de France, and awarded the medal of the society, for his works on the "Aboriginal Tongues of America."

Professor Enrico Caporali, in a paper on the "Pythagoric Formula in Cosmical Evolution," published in the Italian quarterly, "La Nuova Scienza," holds, in general, in opposition to Herbert Spencer's theory of mechanical causes, that all evolution is due more to internal energy than to outward conditions.

The invention of binocular opera-glasses is generally attributed to the Bohemian Capuchin, P. Schyd. M. G. Govi, an Italian investigator, has, however, found that the first glasses of the kind were presented to King Louis XIII, by an optician of Paris named Chorez, in 1620.

Lundstrom has made investigations of the adaptations with which plants are provided for making the most of the water that comes to them in the shape of rain or dew. He has classified them as follows: Depressions in the shape of leaf-cups or of grooves in the epidermis; hair-formations, in tufts or borders; hydroscopic membranes in the shape of larger or smaller spots or stripes on the epidermis; and anatomical adaptations, such as water-absorbing textures and swelling glands. It is a noteworthy fact that all of these adaptations are wanting in the submerged parts of plants.

M. C. André, who is connected with a light-house at Pondicherry, India, tells of a fog-cloud about six feet broad which appeared at the top of the room-wall he was facing, while simultaneously a quick, sharp, and loud report was heard under his table. It sounded as if the whole underside of the table-top had been struck a hard blow, yet the table did not appear to have been moved, nor anything upon it. After the report, his plate took to spinning around on the table without any noise, showing that, though it had been thrown up from the table, it had not ceased to be touching it. This account is a part of the proceedings of the French Academy of Sciences of November 5th, and is designated a "meteorological phenomenon."

M. Philippe Thomas has discovered some very extensive deposits of phosphate of lime in the Tertiary strata of Southwestern Tunis.

M. Ludovic Breton has propounded a new theory of the formation of coal. He believes it is produced by the sinking of floating islands like those which now occur on many lakes and rivers, and which are conspicuous on the Upper Nile. These islands are composed chiefly of turf, which, being swallowed up by the water, becomes fossilized at the bottom.

M. Trève has described to the French Academy of Sciences a phenomenon of a beautiful green ray which he has observed to follow the disappearance, for a quarter of a second after sunset, of the upper limb of the sun's disk. The flash of the ray is as quick as that of lightning, and can be seen only under unusual conditions of clearness of the sky. The author explains the appearance under M. Chevreul's theory of the simultaneous contrast of colors.

M. de Loriol announced to the French Association the completion of his work in the "Paleontologie Française," on the fossil crinoids of France. He has described and figured 209 species, 89 of which are new to science. In the same work M. Cotteau has described 525 species, belonging to 50 genera, of *Echidnæ*. Nearly all of these species are characteristic of the beds in which they are found.

M. Wroblewski has observed that atmospheric air in liquefying does not follow the laws of liquefaction of a simple gas, but behaves like a mixture the elements of which are subject to different laws. If air so behaves that it has been possible, on superficial observation, to speak of its own critical point, it is because the difference in the curves of tension of the vapors of oxygen and nitrogen is so slight as easily to escape notice. Air may be made to give two distinct liquids, of different appearance and composition, one above the other, and separated by a distinct meniscus; the lower liquid containing by volume about 21¼ per cent of oxygen, and the upper one, 17 or 18 per cent.

A Merovingian sepulchre has been discovered near Monteaux, France, which seems to be so far unique in its way, and is supposed to date from the fourth or fifth century. It contained a mummified Frankish warrior, with his arms and clothes. The sarcophagus was made of a soft, calcareous stone, and had lids of the same material. The mummy was wrapped in a linen shirt and a woolen robe, with a belt-buckle in perfect preservation, and an iron sword. The shoes were also in good condition, and fastened with narrow straps of leather. At the feet was a funereal vase. The discoverer had replaced the sarcophagus and covered it up, so as to have it in safe keeping for future observation; but thieves came

in the night to steal it away, and, hardly had they touched the skeleton, when bones, dress, and arms all fell into dust.

M. GASTON TISSANDIER'S "La Nature," of Paris, has just entered upon its fourteenth volume, and, in recording the fact, announces that its career has been one of growing success. It began with a circulation of 2,000 copies, and now prints 15,000. It is a beautifully printed and profusely illustrated journal, whose aim is to direct the studies of French youth, "now eminently industrious and thirsting for knowledge because it has profited by the lessons of a recent past," into the channels which will be most beneficial. Besides recording clearly and concisely what occurs in every other field of science, it gives especial attention to the exposition of new applications of electricity, and of new conceptions and experiments in aërial navigation.

COLONEL B. R. BRANFILL, late of the Survey of India, remarks as a noticeable feature in the meteorology of the southeast coast of that country the frequent lightning-storms, which occur daily, for weeks together, before the setting in of the southwest monsoon, unaccompanied by rain or by any sound of thunder. They are seen along the coast where the land and sea breezes alternate, and along the line of the Ghâts, where the surface-current is thrown up into the upper and opposite current of the atmosphere. In this region the rare phenomenon of interference fringes is very frequently to be seen.

THE purpose of ventilating cellars is to make them cool and dry. They are often ventilated so as to be warm and damp. This is done when the air admitted to them from without is considerably warmer than the air within them. Coming into the cooler cellar, this air, while it raises the temperature of the cellar-air, itself is cooled, and deposits its moisture, which soon becomes evident as visible or palpable dampness. Therefore, all the ventilation of cellars in warm weather should be done at night; and the cellar should be kept closed between sunrise and sunset.

M. TROUVELOT, in a paper about the late "new star" in the nebula in Andromeda, discusses the question whether the star has any physical connection with the nebula. He believes that it has not, because, in proportion as the star diminished again in brightness, the nebula acquired its pristine form. Thus the impression was given that the change noticed in the appearance of the nebula during the conspicuous visibility of the new star was only apparent, and was due to the superior light of the star having overpowered for a time the surrounding portions of the nebula.

M. CH. TELLIER, in a recent experiment, raised twenty-five hundred quarts of water in an hour from a depth of twenty feet, with a power generated simply by the natural heat of the sun.

ACCORDING to accounts in "Land and Water," the gradual extinction of the buffalo is being followed up by an alarming increase in the depredations of wolves upon the sheep and cattle ranches. Both the gray wolf and the coyote are fast becoming more numerous. The sheep have suffered for some time from their ravages, and now the cattle are attacked. One pack of gray wolves, within fifty miles of Fort McLeod, has been known to attack and pull down steers two years old. The coyotes follow the fiercer animals, and are satisfied with what they leave, or with the smaller calves.

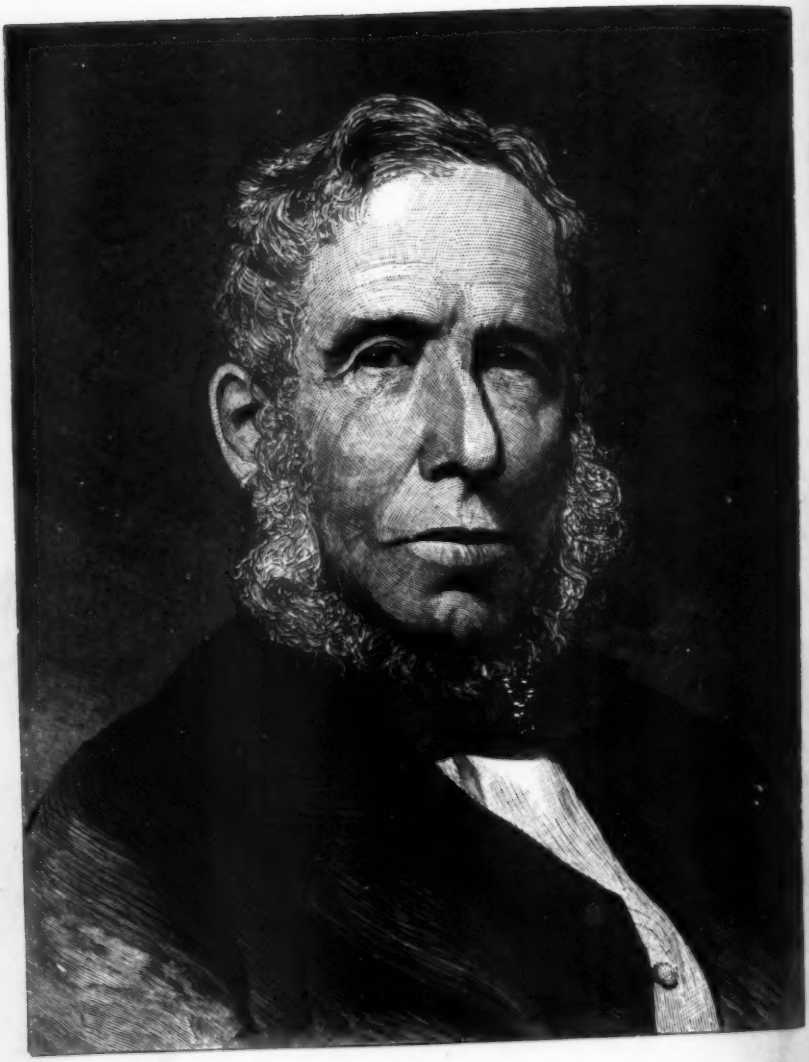
OBITUARY NOTES.

M. BOULEY, President of the French Academy of Sciences, died November 30th, of a disease from which he had suffered long and painfully. His special field of research was in veterinary science, from which he drew many lessons beneficial in their application to human pathology. He appreciated the value of M. Pasteur's labors from a very early stage, and gave them his earnest co-operation; and his own researches in hydrophobia, epizoötics, and their remedies and preventives, entitle him to a distinguished place in the annals of contemporary biology. He was the author of books on experimental disease and on contagion, and his lectures at the museum have been highly spoken of.

THE death is reported of M. Rabuteau, author of valuable researches in experimental therapeutics and chemical physiology. He was particularly interested in the investigation of supposed relations between the chemical composition and the physiological action of various bodies. He was for twenty years one of the most active members of the French Biological Society.

CAPTAIN MANGIN, the inventor of the system of optical telegraphy which has recently been introduced for use in the French army, has recently died of apoplexy, at the age of forty-five years.

DR. THOMAS ANDREWS, F. R. S., for many years, till 1879, Professor of Chemistry in Queen's College, Belfast, has recently died, in the seventy-first year of his age. He made early researches into the liquefaction of the gases, presided over the British Association at the Glasgow meeting in 1876, and in his address predicted the ultimate solution of the question of liquefaction, which was accomplished a year and a half afterward.



JOHN BENNET LAWES.